CLIMATE VULNERABILITY MONITOR 2010

The State of the Climate Crisis

DARA

CLIMATE VULNERABLE FORUM

DARA and the Climate Vulnerable Forum
Climate Vulnerability Monitor 2010 -
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THE CLIMATE VULNERABLE FORUM

is a global partnership of leaders of countries most vulnerable to climate change actively seeking a firm and urgent resolution to the growing climate crisis. The Climate Vulnerable Forum was founded by President Mohamed Nasheed of the Maldives and first met in November 2009. The Declaration of the Climate Vulnerable Forum adopted then expressed alarm at the rate of changes and danger witnessed around the planet due to the effects of human-induced global warming and called for urgent most international cooperation to tackle the challenge.

DARA

is an international organization based in Madrid, Spain, committed to improving the quality and effectiveness of aid for vulnerable populations suffering from conflict, disasters and climate change. Since its foundation in 2003 by Silvia Hidalgo, DARA has conducted independent evaluations of major development and humanitarian assistance initiatives in over 40 countries across five continents, and developed innovative tools to promote the effectiveness of aid and good humanitarian donorship.

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CLIMATE VUL
IN NUMBERS

Nearly
1 MILLION CLIMATE CHANGE DRIVEN DEATHS* ESTIMATED EVERY SINGLE YEAR FROM 2030 IF ACTION IS NOT TAKEN

Some
5 MILLION CLIMATE DEATHS ESTIMATED OVER THE NEXT TEN YEARS IN ABSENCE OF AN EFFECTIVE RESPONSE

Already
350,000 CLIMATE DEATHS ESTIMATED EACH YEAR TODAY

Almost
80% OF ALL CLIMATE DEATHS ARE REGISTERED ONLY AMONG CHILDREN LIVING IN SOUTH ASIA OR SUB-SAHARAN AFRICA

Over
99% OF ALL MORTALITY OCCURS IN DEVELOPING COUNTRIES

Close to
10 MILLION PEOPLE ESTIMATED TO BE LIVING UNDER THREAT FROM CLIMATE DRIVEN DESERTIFICATION BY 2030, UP FROM 2.5 MILLION TODAY

*All estimated mortality statistics or deaths are representative of much wider harm. Every 100,000 deaths would normally indicate several million cases of illness or disability (DALYs), or people displaced, injured or in need of emergency assistance.

NERABILITY

Around
150 BILLION DOLLARS
IN LOSSES TO TODAY'S ECONOMY ESTIMATED TO BE CAUSED BY CLIMATE CHANGE

More than
HALF
OF THE TOTAL ECONOMIC LOSSES TAKE PLACE IN INDUSTRIALIZED COUNTRIES

More than
50
COUNTRIES ACUTELY VULNERABLE TO CLIMATE CHANGE TODAY ARE IN MOST URGENT NEED OF SUPPORT

Some
170
COUNTRIES -- OR MOST OF THE WORLD -- HAVE HIGH VULNERABILITY TO CLIMATE CHANGE IN AT LEAST ONE KEY IMPACT AREA ALREADY TODAY

Over
50
HIGHLY EFFECTIVE MEASURES INCLUDED IN THIS REPORT ARE READILY AVAILABLE TO LIMIT VIRTUALLY ALL HARM CAUSED BY CLIMATE CHANGE -- JUST A GLIMPSE OF THE MANY MORE OPTIONS AVAILABLE

Estimated figures are based on scientific research or expert assumptions in a world marked with uncertainty. The real numbers could be higher or lower.

PREFACE

Climate change is the most urgent challenge of our time. The future of the environment and the life it supports rests on the decisions we take over the coming years. This represents an enormous responsibility on our shoulders, which is not only a burden -- but also a tremendous opportunity for us all.

Previous generations were not aware of the environmental impact of economic development and the resource constraints of our planet. We are. They did not have the technology and the know-how to pursue a different path to prosperity. We do. Our generation must seize this unique moment to build a better, more equitable and more sustainable world. If not, our generation will carry a conscience that will never be clear, from failing to act when we had the chance.

The Climate Vulnerability Monitor lays bare the sheer scale and breadth of the impacts we already face. It breaks ground in pinpointing our vulnerabilities to climate change all around the world. It shows how each country is vulnerable in different ways -- some due to health reasons or extreme weather patterns, and others as a result of economic factors or because of land loss from expanding deserts or rising sea-levels. It explains why many nations at the climate frontline feel the impacts of climate change more intensely. And it demonstrates how quickly vulnerability is accelerating almost everywhere, so that ultimately climate change could threaten the livelihoods, if not the survival, of all nations and peoples. The fate of the world is tied to the fate of the most vulnerable.

THE CLIMATE VULNERABILITY MONITOR LAYS BARE THE SHEER SCALE AND BREADTH OF THE IMPACTS WE ALREADY FACE

Yet such an outcome is not inevitable. The Monitor sends a strong signal of caution. But it sends an equally strong signal of hope.

This report identifies just how inexpensive it is to limit the majority of the negative impacts of climate change seen today, from the effects of the most violent storms and floods, to epidemics, severe drought, desertification, and even rising seas. There are even existing programmes like those addressing the main health issues linked to these causes which can be readily expanded. Countless other signs of hope exist. Countries around the world are beginning to understand that expanding modes of production established in nineteenth century Europe will incur enormous social and economic costs. Shifting to a low-carbon economy, based on green technology and renewable energy, creates wealth, jobs and new opportunities for progress. Many countries of the Climate Vulnerable Forum, despite having contributed little to the climate change problem, are taking the lead in creating this new future. The Maldives, for example, is working to become carbon neutral by 2020. Others among us are pursuing similar pledges.

THE MONITOR SENDS A STRONG SIGNAL OF CAUTION. BUT IT SENDS AN EQUALLY STRONG SIGNAL OF HOPE

The Monitor was built to better identify the needs of communities facing serious climate impacts and to establish a firmer understanding of the nature of the climate crisis as it affects the world's nations today and in the near future. The impact of climate change is already a major global concern, increasingly relevant across areas such as business and trade, civil safety, nature conservation, human rights, and sustainable development.

The Monitor is not perfect. Some of the forecasts and conclusions will

IT IS WELL WITHIN OUR POWER TO SOLVE THE CLIMATE CRISIS

draw criticism for either overplaying or underplaying the seriousness of the problem. This we welcome and encourage. The report's methodology is new. The data worked with is not always ideal. And all predictions are marked by uncertainty and contain a margin of error. But without a report of this kind, the gaps in our understanding might never be filled. It is our hope that future Monitors will benefit from better data and knowledge. We hope the report will trigger more debate and focus more attention on improving our understanding of climate change.

But limitations aside, the types of impacts we will face in agriculture, in health, on the shores of the world's oceans and otherwise are unlikely to fundamentally change. Nor will better knowledge radically alter the truth of underlying vulnerabilities, like poverty or gender inequality, which amplify the impacts of climate change and are present in all societies to varying degrees. Some progress is being made in the global fight against poverty, but the momentum in addressing climate change is only beginning to pick up pace. The negative effects outlined here would just be the beginning if we fail to act.

And let us be frank: time is running out. A near doubling in warming is unavoidable in the next 20 years or so as the lag in the planet's greenhouse effect catches up with us. We must meet this growing challenge. If not, the Monitor estimates that by 2030, over 130 countries will be highly vulnerable to climate change; while over 50 countries will suffer the kinds of acute impacts that just a handful of particularly fragile states are experiencing today. According to the scientific consensus, we must also begin reversing our patterns of emissions within the next five years to avoid even greater temperature change and greater harm.

As with every study of this kind, the Monitor lacks complete certainty, but highlights enough threats of serious, or even irreversible, harm that inaction is unconscionable. This report should act as a wake-up call to decision makers and to people everywhere that more, much more, has to be done, and quickly.

There is still time to act and it is well within our power to solve the climate crisis. A world free from pollution would be healthier for everyone; renewable technologies could bring energy to many who have no access today; protecting communities against climate impacts will bolster the fight against poverty; and everybody would enjoy a safer, more prosperous world.

Is the world ready to act?

Those of us who believe in the potential of climate change, both as a threat and as a stimulus to kick-start a new twenty-first century revolution -- this time grounded in green growth and truly sustainable development -- should not despair. We must highlight the scale of the problem, now and in the future, and demonstrate the available options for an alternative route. And we must argue -- and win the debate -- that it is in all of our interests to act now and act together. Each of us has common but differentiated responsibilities and abilities. But climate change should not divide us. Quite the opposite -- it must unite.

CLIMATE CHANGE SHOULD NOT DIVIDE US. QUITE THE OPPOSITE -- IT MUST UNITE

The Climate Vulnerability Monitor is our contribution to the global debate. We hope that you will find it useful in your efforts.

MOHAMED NASHEED
President of the Maldives
Founding Chair,
Climate Vulnerable Forum

JOSÉ MARÍA FIGUERES
Trustee, DARA
Former President of
Costa Rica (1994-1998)

"Article 3. Principles. 3.
The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost."
– United Nations Framework Convention on Climate Change (UNFCCC), Rio de Janeiro, Brazil, 1992

"Humanitarian action should be guided by the humanitarian principles of humanity, meaning the centrality of saving human lives and alleviating suffering wherever it is found..."
–Principles and Good Practice of Humanitarian Donorship, Stockholm, Sweden, 2003

"The fate of the most vulnerable will be the fate of the world."
– First Declaration of the Climate Vulnerable Forum, Male', Maldives, 2009

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ABOUT THIS REPORT
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CLIMATE VULNERABILITY MONITOR
A global assessment of vulnerability to different aspects of climate change including its Health Impact, Weather Disasters, human Habitat Loss and Economic Stress on key industries and natural resources. The Climate Vulnerability Monitor is a new tool aimed at advancing understanding of the impact climate change has on human society and actions needed to address the harm this causes.

ADAPTATION PERFORMANCE REVIEW
A catalogue of measures and programmes valuable for reducing the negative effects of climate change in the areas of health, extreme weather, degradation of human habitats and other stresses to the economy and the environment.

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RESEARCH GAPS
Knowledge limitations that must be urgently addressed in order to improve our understanding of climate change and its impact on communities around the world. Filling these gaps will be vital for effectively tackling the climate challenge.

FINDINGS A OBSERVATI

A HOTTER EARTH IS ALREADY CAUSING WIDESPREAD DAMAGE AND DEATH.

The artificial heating of our planet fuelled by human activities already interferes with earth's delicate climate leading to effects that are dangerous for people and nature. The alarming rate of change and spiralling effects of heat, wind, rain, deserts, sea-levels, and other impacts on the world's populations leave a human toll of 350,000 deaths every single year. Stifling heat, winds, and water shortages pressure the lands of some 2.5 million people in arid regions degrading into desert. The effect of climate change on storms, floods, and wildfires is estimated to leave an additional 5 billion dollars (USD) of damage each year, while rising seas cost 1% of GDP to the lowest-income countries – 4% in the Pacific – with annually 65 billion dollars wiped off the world economy. Globally, the primary sectors and fisheries are already weighed down by a further 65 billion dollars every year from climate stresses.

MOST IMPACTS ARE HIGHLY CONCENTRATED ESPECIALLY ON CHILDREN AND THE POOR.

Over three quarters of the death toll linked to climate change is concentrated on children living in Sub-Saharan Africa or South Asia. Gradual, not sudden, impacts from climate change cause more than 90% of all damage. The roughly 50 least developed countries suffer more than one third of the global human toll linked to climate change, and emerging economies nearly two thirds. Overall, the few additional deaths in wealthy countries are likely offset by health gains due to warmer, shorter winters and other effects. Over 80% of people at risk from climate-driven desertification reside in high-growth emerging economies such as China and India. Half of the economic impacts of climate change are felt in industrialized countries. However, lower-income countries suffer much greater relative stresses to their economies, mainly due to larger, less-robust agricultural sectors. Some 50 countries are considered acutely vulnerable to climate change today, collectively suffering most of all climate impacts. Recognized fragile or failed states like Afghanistan, Haiti, Myanmar, Sierra Leone, and Somalia are among the worst affected, as are low-lying island nations facing existential threats. An average of just 24 countries are assessed as having the most severe factor of vulnerability for each main impact area of health, extreme weather, habitat loss, and economic stress. In every case, some two thirds of the total global impact falls on just 10 countries.

ND ONS

MUCH DAMAGE CAUSED BY CLIMATE CHANGE IS STILL READILY PREVENTABLE.

Half or more of today's human toll linked to climate change could be prevented with targeted distribution of salt-water solutions or basic dietary or vitamin supplements costing virtually nothing. A wide array of cost-effective actions can be taken to reduce climate vulnerabilities for each of the Monitor's four impact areas. Measures that reduce the impacts of climate change on health are the most effective, followed by those that reduce exposure to extreme weather. Preventing loss of human habitat to desertification, sea-level rise or loss of biodiversity, such as alpine species or coral, are the most challenging to address, but several relatively inexpensive and proven measures nevertheless exist. Greater impacts are inevitable however, and eventually damage may only be able to be limited or selectively avoided. But the worst impacts of climate change for which several measures would become futile can still be avoided if strong action is taken in the very near future to reduce greenhouse gas emissions that lead to the earth's warming. Enough market-viable opportunities also exist to substitute carbon-intensive means of production, transportation, and energy creation or avoid deforestation for an immediate and sustained transition to a low-carbon economy, which would stem the root causes of climate change.

THE CLIMATE VULNERABILITY MONITOR IN BRIEF

The Climate Vulnerability Monitor takes a new approach to assessing the climate vulnerability of the world and its regions, countries and communities. The Monitor looks at pre-existing characteristics of society that are knowingly affected by climate change and maps the level of vulnerability and expected impacts as implied by the effect that real or projected changes in the climate will have on these. The Monitor uses globally comparable information in order to establish reference points across countries. The Monitor's analysis is built around four distinct climate impact areas, five levels -- called factors -- of vulnerability to climate change, and two points in time, 2010 and 2030. The impact areas were chosen because they represent most of (but not all) the main impacts of climate change and form distinctive types of responses in each area -- although some measures to reduce impacts or vulnerability could have beneficial effects across several or all impact areas. The vulnerability factors are determined statistically and indicate how different an effect is expected to be from a baseline of zero impact due to climate change. The factors remain static from 2010 to 2030 demonstrating how vulnerability would evolve under climate changes expected over the next 20 years if measures are not taken to reduce vulnerabilities. Climate change is never linked to any specific event, but considered an added stress, effect, or change that carries consequences we consider positive or negative. The estimative figures of impacts mentioned in this report are yielded from the Monitor's specific methodology and represent additional impacts due to climate change. They are a plausible snapshot of what is expected to already be taking place and what might eventuate in the near future. Wherever possible leading expertise and scientific modelling has been relied upon (see "Climate Vulnerability Monitor Architecture", p.54). Still, there are gaps in the base data the tool relies on as well as gaps in several research areas that restrict our full understanding of the effects of climate change.. The Monitor represents just one possible way of measuring climate vulnerability that we expect can be greatly and continually improved upon.

CLIMATE IMPACT AREAS

- HEALTH IMPACT - additional mortality to climate sensitive diseases
- WEATHER DISASTERS - additional mortality and damage in storms, floods and wildfires
- HABITAT LOSS - additional loss of human habitat to rising seas, and degrading arid lands
- ECONOMIC STRESS - extra losses in the primary/agricultural sectors of the economy and to key natural resources

CLIMATE VULNERABILITY FACTORS

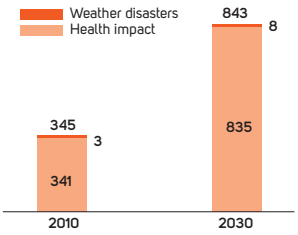
- ACUTE (most vulnerable category)
- SEVERE
- HIGH
- MODERATE
- LOW (least vulnerable category)

UNLESS MEASURES ARE TAKEN, THE NEXT 20 YEARS WILL SEE EXPLOSIVE GROWTH IN EVERY MAJOR CLIMATE IMPACT.

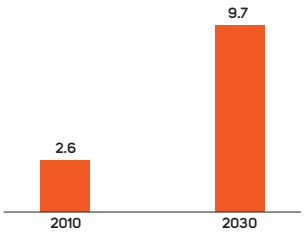
Twenty more years of inaction would lead to nearly 1 million climate deaths a year by 2030. The number of acutely-vulnerable countries would more than triple over that period with nearly half of the world's regions entering the ranks of the most vulnerable. Ten million people a year exposed to desertification and sea-level rise could lead to a relocation exodus. Economic costs would leap to 100 billion dollars of stress on the world's coastlines, 150 billion dollars worth of primary-sector and natural resource losses, and 10 billion dollars in storm, flood, and wildfire damages -- in a third of a trillion dollar annual economic crisis. By 2030, 132 countries would register an overall factor of High vulnerability or above. Unless actions are taken to meet the challenge by 2030, 42 countries would become acutely vulnerable to the health impacts of climate change, 20 countries to extreme weather, 48 countries to loss of human habitat, and 68 countries to wide-ranging economic stresses.

GLOBAL CLIMATE CHANGE IMPACT

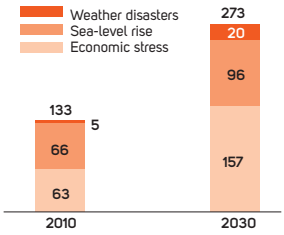
CLIMATE-RELATED MORTALITY. ADDITIONAL DEATHS (1000) AVERAGE PER YEAR



PEOPLE AT RISK FROM CLIMATE-RELATED DESERTIFICATION. ADDITIONAL (MILLIONS) AVERAGE PER YEAR



CLIMATE RELATED ECONOMIC COSTS (BILLION USD PPP) AVERAGE PER YEAR

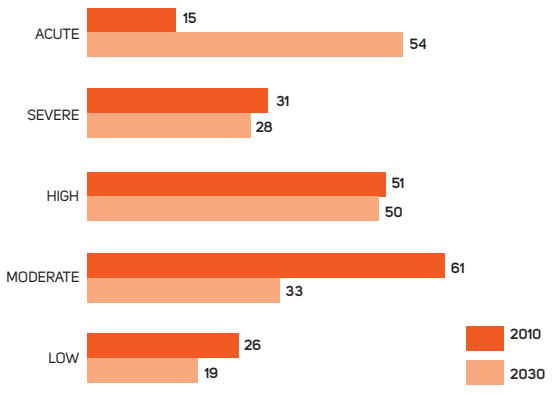


ALMOST EVERY COUNTRY HAS HIGH VULNERABILITY TO ONE MAJOR CLIMATE IMPACT.

Nearly every single country – 161 to 176 of the 184 countries assessed – registers high vulnerabilities to at least one climate change impact area (2010 to 2030). Most countries in the world are therefore facing climate insecurities of one kind or another, whether due to heat waves; wildfires, floods, and storms; economic losses in key sectors; ecosystem damage; or hunger, disease, and displacement. Climate stresses on the economy are the most widespread and include lost value in the agricultural sector, including forestry and fisheries, as well as impacts for natural resources like water and biodiversity. The next most-prevalent impacts are in losses to human habitat as a result of growing desertification and sea-level rise. In 2010, health impacts due to climate change are least dispersed, but they are set to expand, with some 55 countries attaining a vulnerability factor of Acute or Severe by 2030 (compared to just 34 countries similarly prone to extreme weather by that time). While most wealthy countries register a factor of High vulnerability in at least one impact area, only Spain and the United States have an overall vulnerability factor of High, which is similar to major emerging economies such as China, Indonesia, Iran, Philippines, and Thailand.

GLOBAL VULNERABILITY TO CLIMATE CHANGE

Number of countries per climate vulnerability factor



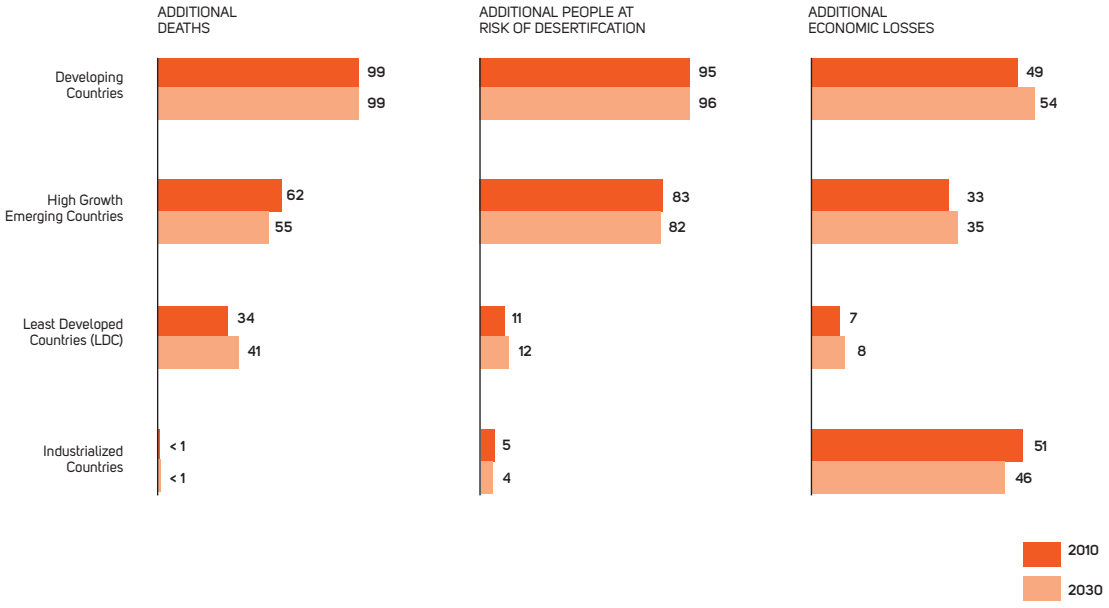
LOW HUMAN DEVELOPMENT INCREASES VULNERABILITY TO CLIMATE CHANGE WHILE CLIMATE CHANGE THREATENS KEY DEVELOPMENT GOALS.

Every increase in vulnerability to climate change brings a greater likelihood of poverty, gender inequality, and lower human development. The Monitor also identifies countries with much higher climate vulnerability than their human development level would imply. In particular, countries with very low human development and very high climate vulnerability, including a number of highly fragile states, such as Afghanistan and Somalia, should be singled out for special attention. The impacts felt in some of the world's most acutely vulnerable countries may well be too extreme to be fairly reflected when considered in relation to other countries. Strong societal fabric, governance, gender equality, and the rule of law will help diminish climate vulnerability and facilitate the implementation of effective countermeasures to the worst effects of climate change.

But climate change itself also wears down progress towards the Millennium Development Goals (MDGs), above all in the areas of extreme poverty and hunger where the world is not on track to meet its 2015 targets of eradication. If action is not taken, climate change risks threatening or reversing progress made in reducing child mortality and fighting major infectious diseases such as malaria.

SHARE OF TOTAL CLIMATE CHANGE IMPACT ON SOCIOECONOMIC REGIONS

% of total impact, Additional Deaths, Additional People at Risk of Desertification, Additional Economic Losses



Abandoned mud houses surrounded by flood waters following extremely heavy rains in Aweil, Sudan. Source: UN Photo/Tim McKulka.

TACKLING CLIMATE CHANGE IS A MAJOR OPPORTUNITY.

Right now, the same steps that minimize vulnerability to climate change collectively contribute to every major global target for poverty eradication and to the improvement of living standards. Effectively tackling climate impacts will be vital to bringing the international community back on track to achieving the MDGs in just five years' time. But opportunities will fade as warming increases. It will become more and more difficult to deal at a local level with global forces such as warming and rising seas as adaptation increasingly comes to involve choices about what to preserve. And protecting communities and the environment will be brought into ever-greater competition with narrow economic interests as costs ultimately become prohibitive.

Tackling the root causes of climate change is also a major opportunity. Adopting greener practices in a low-carbon economy will bring major societal benefits. Fossil fuel pollution itself is a leading risk factor for a significantly greater human toll than the climate change it triggers -- it was estimated to be the cause of close to 3 million deaths worldwide in 2000.[1] The exploitation of increasingly scarce fossil fuels is also causing ongoing damage to the environment, as was glaringly demonstrated by the 2010 Gulf of Mexico oil spill disaster; and leading to human tragedies such as coal mining accidents in places as diverse as China or New Zealand. Decentralized forms of renewable energy are much safer, cleaner, and hold significantly more promise for the 20% of the world's population who have no electricity or grid system to access traditional sources of energy produced by large-infrastructure power plants. A green technology revolution could well hold the key to unlocking the global inequities that continue to plague the world as a result of unequal access to energy and other resources.

RECOMMEND

DANGER IS PRESENT. RESPONSES ARE COST-EFFECTIVE. INACTION IS UNCONSCIONABLE.

While climate change is fact, the science of its impacts is not yet exact. The full extent of its effects on communities remains uncertain. But we have enough indications to suggest widespread harm and danger is already being done all over the world. And we can tackle that harm with cost-effective measures readily at hand for limiting impacts and reducing greenhouse gas emissions that cause the warming -- both of which must happen in tandem. Major emitters must assume responsibility for this crisis in accordance with common but differentiated responsibilities and respective capabilities. Immediate action is needed to prevent further warming of the planet and any harm caused by warming we can no longer stop. We are already committed to levels of warming that could entail mass extinctions of species, the disappearance of the world's coral reefs, and much greater impacts on human society than are outlined in this report.[2] But the quicker we act, the more we reinforce the ability of vulnerable communities to withstand the changes, the more we can limit additional warming, and the more we can avoid the most devastating of consequences for this planet and the life it supports.

EXPAND HUMAN AND GENDER DEVELOPMENT EFFORTS IN MOST-VULNERABLE COUNTRIES.

Climate change is already placing a burden on poverty-reduction efforts and is contributing to significant lost GDP potential in a number of worst-affected countries. The countries most vulnerable to climate change have the highest levels of gender inequality and the lowest levels of human development. Reinforcing the drive for climate-friendly development progress on all fronts is a crucial complement to any response aimed at reducing vulnerability to climate change. In particular, many of the countries most acutely vulnerable to climate change are also fragile states, on the limits of human development and stable social and political order. Elsewhere, low-lying island nations are facing imminent existential threats that significantly undermine development. In worst cases, vital efforts to manage fast-depleting natural resources such as water, or even the types of practical measures featured in this report's Adaptation Performance Review and in national plans (NAPAs), will face serious implementation challenges in countries with inadequate public institutions, unstable socio-political environments, or situations of armed conflict. Support to developing countries, in particular including facilitated access to green technologies, will be crucial for supporting sustainable development.

IMMEDIATELY REINFORCE RESPONSES TO MAJOR CLIMATE-SENSITIVE HEALTH CONCERNS: MALNUTRITION, DIARRHEAL INFECTIONS, AND MALARIA.

Contrary to popular notions, the vast majority of human deaths linked to climate change are not caused by stronger storms and floods. Instead they are the result of climate-sensitive disease. Climate change is already causing an estimated 350,000 deaths -- and more than 10 million cases of illness every year -- mainly due to malnutrition, diarrheal infections, and malaria.[3] Higher temperatures, water shortages, and other impacts are weighing down the fight against some of the world's most deadly diseases. Less than a quarter of existing national adaptation programmes of action (NAPAs) in most vulnerable countries adequately address health impacts due to climate change, including just 3% of priority projects that target health.[4] Yet exceptionally cost-effective and established measures such as bed nets, dietary supplements, and oral rehydration therapies consisting of just water, salt, and sugar are readily available to help avert any additional deaths and reduce the extent of major climate-sensitive illnesses in the worst-affected areas.

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INVEST IN FILLING URGENT RESEARCH GAPS.

While we already have enough sound research and analysis available to point to serious dangers and harm taking place around the world and to take measures against those impacts. A more accurate and comprehensive understanding of the impact of climate change on human society is impeded by major gaps in research, science, and socio-economic knowledge. This report leaves out countries and known effects of climate change due to the absence of adequate data or research. Some key areas of socio-economic impact have clearly unsatisfactory or non-existent scientific bases for their estimation. And measures of the success of policies and actions to limit the negative effects of climate change are still inadequate. The Climate Vulnerability Monitor was built not only to improve responses to these effects but also to reveal the limitations on our knowledge and spur debate aimed at a better understanding of the impact of climate change. A detailed list of the main research gaps encountered during the development of the Monitor is found in this report. Urgent investment is needed to close those gaps. And national governments must also improve their mapping of human vulnerability to ensure that adaptation resources reach the most vulnerable. If such gaps are not dealt with, we risk seriously underestimating or adding unnecessary ineffectiveness to our response to this crisis when so much is already at stake.

WIDELY DISSEMINATE THE CLIMATE VULNERABILITY MONITOR'S FINDINGS.

The lack of public support for ambitious climate change policies continues to be a major impediment to mobilizing an effective response to this crisis. Political leadership on the issue is also weak, partially because of public indifference. A successful international agreement able to tackle the climate problem relies on national decisions based on the level of action (especially to reduce emissions) a country is willing to assume. Unfortunately, public and political concern is especially low in major emitting countries whose role is central to any solution to this crisis. The dynamics of international media and the politics of climate change mask a clear scientific consensus on global warming, its causes, and some of its key effects, feeding scepticism that undermines support for action desperately needed to tackle this issue. The findings of this report should therefore be subject to the widest possible dissemination with the goal of ensuring that everyone can at least be informed of the types of dangers we run by not tackling the climate crisis.

REINFORCE NATIONAL PLANS TO LIMIT CLIMATE IMPACTS.

Warming of the planet beyond the 0.8 degrees Celsius (1.4 degrees Fahrenheit) already seen since the industrial revolution is set to double or even possibly triple over the next decades.[5] The humanitarian and environmental effects of this rapid warming should not be underestimated and will require large-scale responses in order to limit the harm done. Most countries highly vulnerable to climate change also lack resources and require external support to combat the additional stress it places on their communities, their economies, and their ecosystems.

Least developed countries have put together initial programmes (NAPAs) to respond to the local effects of climate change that are to be externally financed, but which still go largely unfunded despite many of them now being several years old. Non-negotiable resources derived from major emitters should not only be immediately released in order to realize these plans in their entirety -- and especially to implement priority projects, which amount to less than 2 billion dollars (USD) globally.[6] The scale of impacts captured in the Monitor would imply that NAPAs are already inadequate to deal with the negative effects of climate change impacting vulnerable communities around the world. So national plans must be expanded in kind, in particular with respect to human health, where hundreds of thousands of lives are already being lost with every single year of inaction.

But the rapid growth and widespread prevalence of vulnerabilities around the world imply that virtually all countries, especially all developing countries, should be preparing and implementing plans in order to protect populations and resources. Findings across the various impact area assessments of the Monitor serve as bare-minimum proxy indications for wider effects that must be addressed if harm resulting from climate change is to be prevented. International adaptation finance should be stepped up without further delay to protect communities at risk via a global funding mechanism with legitimate and inclusive decision-making processes.

ABOUT THIS

WHY THIS REPORT NOW?

DARA and the Climate Vulnerable Forum created the Climate Vulnerability Monitor to advance understanding of the growing negative effects of climate change on society and to identify a variety of key options to meet this new challenge.

Climate change is a global problem whose resolution requires global cooperation. As a result, global policies, legislation and collaboration frameworks, formal and informal, are under discussion if not already in place. It is critical that any global actions that stem from these efforts be informed by a clearer picture of what is at stake today and tomorrow as a result of climate change on a global level. Despite a wealth of knowledge on climate change, little consolidated information has so far been made available regarding the types, scales, and locations of its impacts around the world today.

CLIMATE CHANGE IS A GLOBAL PROBLEM WHOSE RESOLUTION REQUIRES GLOBAL COOPERATION

The Climate Vulnerability Monitor comes forward as a contribution to the debate in this respect. It is also entering publication against a context of slow progress on measures being taken to deal with impacts that climate change is already having around the world today. Negative effects are most often triggered when a community is unable to deal with small additional stresses. Vulnerability, or inability to withstand change or harm, varies greatly from community to community -- as do changes in weather and existing climate conditions. Wealthier communities may hardly notice changes that in other regions could well be life threatening. Flood defences or sophisticated health systems able to cope with new challenges in one place may be non-existent elsewhere. Impacts are worsened when local environmental conditions are already difficult due to water shortages, land degradation, or otherwise. When pre-existing environmental challenges, changing climate conditions, and vulnerability are all at their highest, the consequences can be devastating. And people suffer.

Progress, meanwhile, towards an international agreement on climate change that might halt the planet's warming is painstakingly slow. With failure to reach a binding agreement at the Copenhagen climate summit in 2009 and no real signs of a breakthrough since, are we oblivious to the scale of the climate crisis already evident before us? A near doubling in temperature increase with correspondingly greater impacts over the next few decades is unavoidable and something we must prepare for. Far more serious damage and destruction than is outlined in this report can still be averted but will require a steady reduction in global greenhouse gas emissions that trigger the warming effect. That effort must begin in just the next few years, or we may well risk heating up the climate system beyond control, with ever worsening consequences.

ARE WE OBLIVIOUS TO THE SCALE OF THE CLIMATE CRISIS ALREADY EVIDENT BEFORE US?

The lack of specifics on what is happening may well be holding back international cooperation and is even more likely to be restraining support to vulnerable

REPORT

communities that are inadequately equipped to face what, in some cases, is becoming an existential threat. Policy-makers, in particular, have had little indication about the relative sizes or breadth of the different stresses taking hold. And financial resources are difficult to mobilize for a problem that has no clear form. All of this has also kept people out of touch with the realities of a global crisis when strong public support is now so crucial to resolving the problem.

Yet well-researched if imperfect explanations of the effects of climate change on communities around the world do exist, as does information on the effectiveness of measures to limit any harmful effects. This report aims to bring such expertise to bear in response to simple questions: Where and how is climate change having its most serious effects? To what degree? And what measures can we take to minimize the harm? In this way, the report seeks to clarify the extent of the main impacts of climate change on human society and identify some of the most effective responses to that impact. It also aims to point out those areas where limits to our knowledge constrain a more accurate understanding of this challenge -- and a better response.

THE APPROACH

The purpose of the Monitor is to begin to provide an assessment of different kinds of vulnerabilities and to pinpoint who faces them, when, and where. The intention is to help guide, not to prioritise by exclusion or to provide some sort of assertive and closed list of preferences. It is not meant to rank some countries as vulnerable and others as not. The report is global, with information given on a country level, but not below that level except in isolated areas. The approach is pragmatic, aimed at establishing robust comparable estimates for the main types of impacts that are occurring, to better ensure we are dealing with them, and to better identify hurdles that stand between us and a more accurate picture of what is happening.

The report consists of three main parts. First is the Climate Vulnerability Monitor itself, which provides a map of key vulnerabilities to climate change across four major impact areas: Health, extreme weather, loss of human habitat, and stresses on the economy and natural resources. Second is a catalogue of some key practical actions that can be taken to reduce impacts identified in the Monitor. Third, is a limited set of country profiles that illustrate how the findings of the Monitor relate to a given country's situation.

The Climate Vulnerability Monitor is just one of many possible approaches to gauging vulnerability to climate change. The chosen methodology of the Monitor generates the results as outlined in this report. Other methodologies have and will lead to different findings.

This report understands "climate vulnerability" as the degree to which a community experiences danger and harm from the negative effects of climate change.[7] That definition is taken to include both the characteristics of a particular community -- or *underlying* vulnerability -- and exposure to changes in climate conditions and weather -- or *physical* vulnerability -- both of which vary greatly around the world. The Monitor is not assessing adaptive capacity or resilience per se, but what results when combinations of climate stresses affect a specific community. Countries with lower vulnerability and impacts will invariably have higher adaptive capacity and resilience. The Monitor's focus on estimated negative or positive outcomes -- *impacts* -- triggered by the presence or absence of vulnerabilities differs from other tools. And "vulnerability" and "impacts" that *highlight* vulnerabilities are used somewhat interchangeably across the report.

The Monitor provides an indication of the scales of harm, or in some cases benefits, being triggered by climate change. This assists the targeting of actions that seek to reduce harm, such as those mentioned in the Adaptation Performance Review. But the Monitor also reveals important information about broader strategies to deal with vulnerability, such as the relationship between climate vulnerability and human development or gender inequalities. This information can be used to inform strategic socio-economic or development planning not covered in the Adaptation Performance Review.

The Adaptation Performance Review itself provides an assessment of practical, concrete measures that can be taken to reduce vulnerability and negative impacts due to climate change. “Adaptation” is taken to mean any actions that help communities or their ecosystems cope with a changing climate.[8] The Adaptation Performance Review assesses actions for their effectiveness in reducing impacts that have been pinpointed in the Monitor. It only includes actions for which reliable information on cost-effectiveness and other key features of programmes has been readily available. It is non-exhaustive, but provides a useful indication of the array of options available to limit impact and the varying degrees of cost-benefit returns that apply to each main impact area.

WHAT ARE THE REPORT'S LIMITATIONS?

In general, the measures of vulnerabilities relied upon and sometimes the indicators of impacts given are not always ideal. The information drawn on must be comparable across the board and is often limited to the lowest common denominator of what is available globally -- in fact a handful of countries are excluded for not meeting even minimal data requirements, leaving a total of 184 countries assessed. Countries are not the best unit of analysis for climate changes, which may vary considerably across one nation. Climate scientists differ in their agreement on key changes -- such as tropical storm activity -- and the models themselves vary in their confidence or certainties in predicting a role of climate change today and in the near future, as well as in predicting where, for instance, changes like rainfall will ultimately occur. Neither do changes in weather conditions necessarily translate to effects on the ground in the same degree -- and yet, in some cases, there are simply no better estimates available. Occasional discrepancies in records used also have some effect on the accuracy of this report’s assessments. Overall, estimates of impacts could be higher or lower. However, they are more likely too conservative, if only because a number of known impacts have simply been excluded -- such as effects on freshwater marine life, infrastructure damage from permafrost melt, and many others -- which could well be significant to certain communities if not globally.

Despite these shortcomings, the rough picture this report sets out is still likely to be reasonably accurate. Most of the main impacts of climate change are covered and linked to well-researched scientific models. If adaptation efforts were put into effect to address the levels of impacts outlined here, vastly fewer human lives would be at risk, and many endangered species could be spared -- for the most part at a very low cost. It is also important to remember that most adaptation efforts also strengthen the general well-being of vulnerable communities and the world.

WHO DOES THE REPORT SERVE?

The report aims to be useful for a wide range of groups. It should complement in particular the array of tools already available to policy-makers and decision-takers. Senior officials at a national level will have an idea of the extent to which additional stresses due to climate change

Sandstorms are becoming increasingly common in Iraq. Source: Sinan Mahmoud/IRIN.

are likely weighing down or relieving a country's health system or the economy, damaging infrastructure and natural resources, or pressuring coastal or dryland communities. And one that is comparable to effects seen elsewhere.

Anywhere beyond moderate vulnerability implies that a country is experiencing a level of impacts significantly more than the average seen worldwide. Responses should be able to match, at minimum, the levels of indicative impacts mentioned in this report in order to bring vulnerabilities back to acceptably low levels. Detailed sub-national and community planning will be necessary in all cases, since measures take place on these scales. But if a national plan is in distinct misalignment with the Monitor, there is likelihood that some impacts may be going unaddressed, if not, the case could be used to help evolve the Monitor itself -- either way it would merit further investigation.

International experts involved in designing or organizing responses, including humanitarian and development actors, could also use the report to improve the identification of key vulnerabilities linked to climate change and enhance the targeting of strategies, advance planning and other activities that tackle these. It will take much preparation to counteract the rapid growth in negative impacts expected over the next 20 years as a result of the increased warming of the planet.

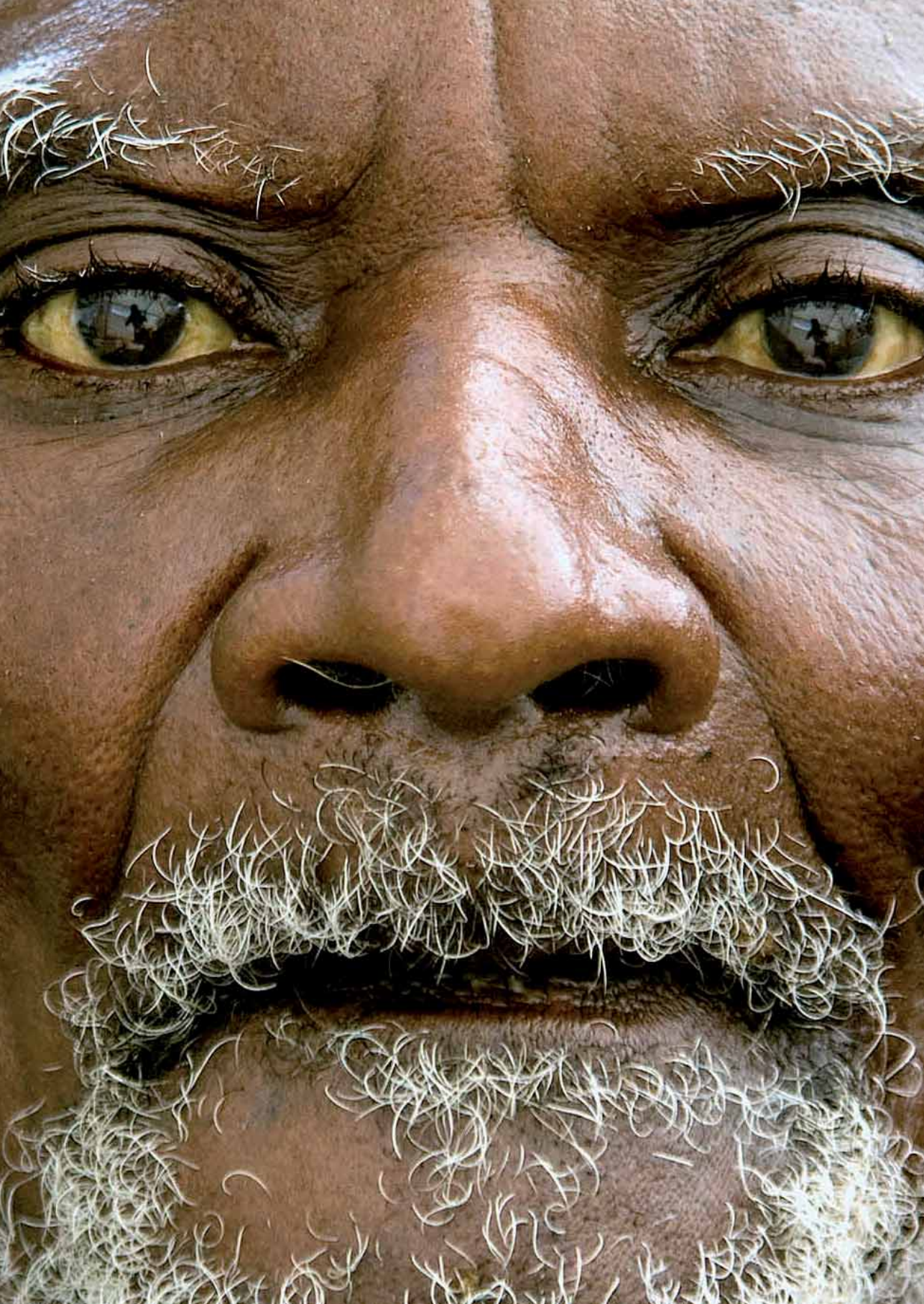
In general, international climate negotiators, politicians, government officials, community groups, and the media could all benefit from a familiarization with this plausible snapshot of the growing climate crisis that the Monitor provides.

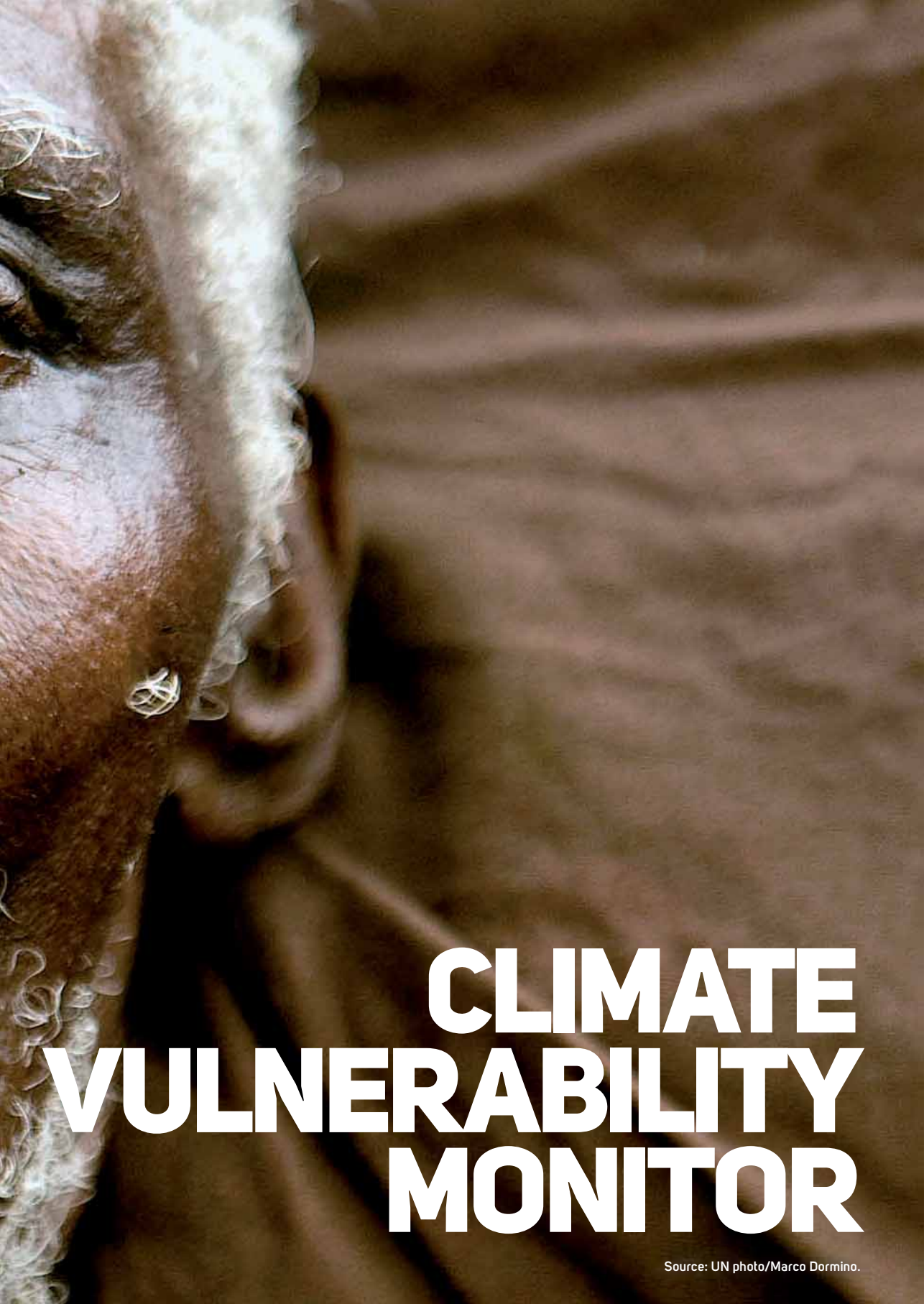
HOW WAS THE REPORT DEVELOPED?

The report has been produced by DARA, an independent humanitarian organization specializing in expert evaluation and analysis of humanitarian assistance and development aid, with the support of its research partner Commons Consultants, and local expertise and guidance provided by experts in Climate Vulnerable Forum (CVF) countries and other leading specialists and partners. The CVF itself is a unique partnership of leaders of countries worst affected by climate change from all regions of the world seeking an enhanced global response to climate change. This report is issued as part of the DARA-CVF Climate Vulnerability Initiative.

The Monitor was commissioned in order to better ascertain the current and short-term dangers of climate change. Expert groups were established to assist with the development of an independent tool able to assess in a comparable way the climate vulnerability of nations, regions, and of the world. This first Monitor has already benefitted from the advice of leading experts from mainly climate change, development, and humanitarian backgrounds, which act as advisors to the Climate Vulnerability Initiative project and offer input on the content of the report. The tool was to provide mean estimates of the different levels of impacts being felt by populations around the globe with an indication of how those impacts would evolve in the near future. This first report publishes the results and methodology of that tool in full transparency. The intention is for it to serve as a departure point for generating discussions aimed at refining our understanding of climate vulnerability and improving both the methodology and the accuracy of this tool going forward. In seeking to improve understanding of the impact of climate change on human society, the report strives to:

- Better match responses to the needs of the most vulnerable communities
- Ensure that the public and decision-makers know what is at stake
- Encourage research to fill the major gaps in our understanding of this field





CLIMATE VULNERABILITY MONITOR

Source: UN photo/Marco Dormino.

THE CLIMATE VULNERABILITY MONITOR

The Climate Vulnerability Monitor provides a global overview of our vulnerability to climate change. It provides fair estimates of the types of impacts we are already facing due to changes in our climate. It shows where those impacts are taking place -- with most of the harm falling on already poor and vulnerable communities. The Monitor also captures our evolving vulnerability to climate change, which is on the rapid increase globally.

INTRODUCTION

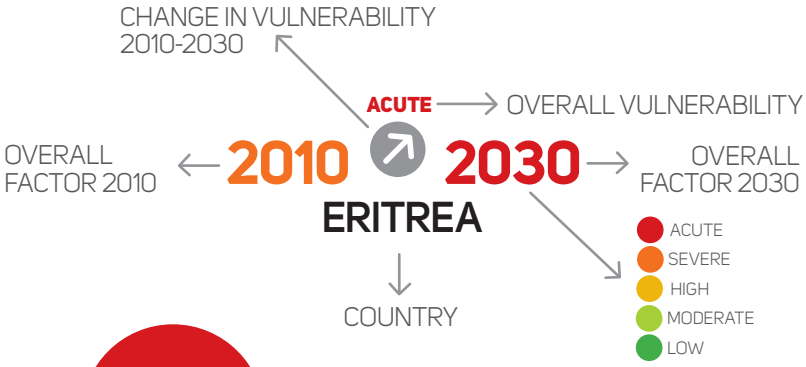
When monitoring estimated impacts of climate change on populations around the world it becomes immediately clear to what extent humanity is already in the depths of a fundamental and dangerous crisis. Most of the world's countries are already suffering negative impacts due to climate change in at least one or two different areas today. Only a few are experiencing any benefits. And these are far outweighed by the levels of damage and harm seen elsewhere. More than 50 countries will be acutely vulnerable to these effects by 2030 if measures are not taken to minimize the harm. Hundreds of thousands of lives are estimated to be lost with every year of inaction that goes by. The impacts are already so widespread that this challenge is endemic: A dozen regions register a factor of Acute vulnerability in at least one impact area.

It is possible to reduce vulnerability, of course. This report's Adaptation Performance Review outlines cost-effective measures for tackling all of the different types of impacts covered by the Monitor. For every factor increase in vulnerability there is also a corresponding drop in human development. The link between poverty and vulnerability to climate change could not be clearer. And a strategic reinforcement of human development strategies will also be critical in meeting this new challenge.

If we continue on the current path, in the next 20 years alone the number of most-vulnerable countries will double that of today. We can still take action to reverse this trend and stop the deadly and harmful impacts. If we do not act, vulnerability can only worsen. Fleeting benefits will vanish. And all nations will realize, one-by-one, an inevitable, global, vulnerability to a disrupted climate.

IF WE DO NOT ACT, VULNERABILITY CAN ONLY WORSEN. FLEETING BENEFITS WILL VANISH. AND ALL NATIONS WILL REALIZE, ONE-BY-ONE, AN INEVITABLE, GLOBAL, VULNERABILITY TO A DISRUPTED CLIMATE

GUIDE TO THE MONITOR



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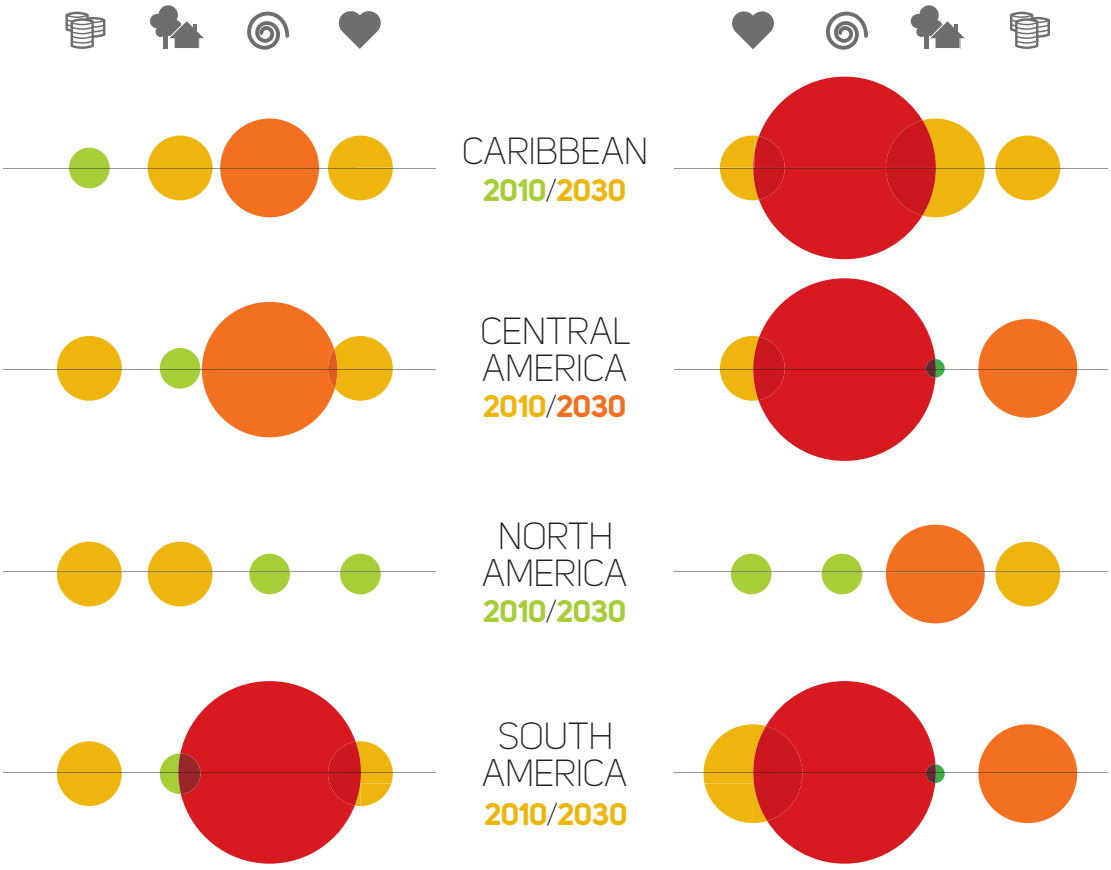

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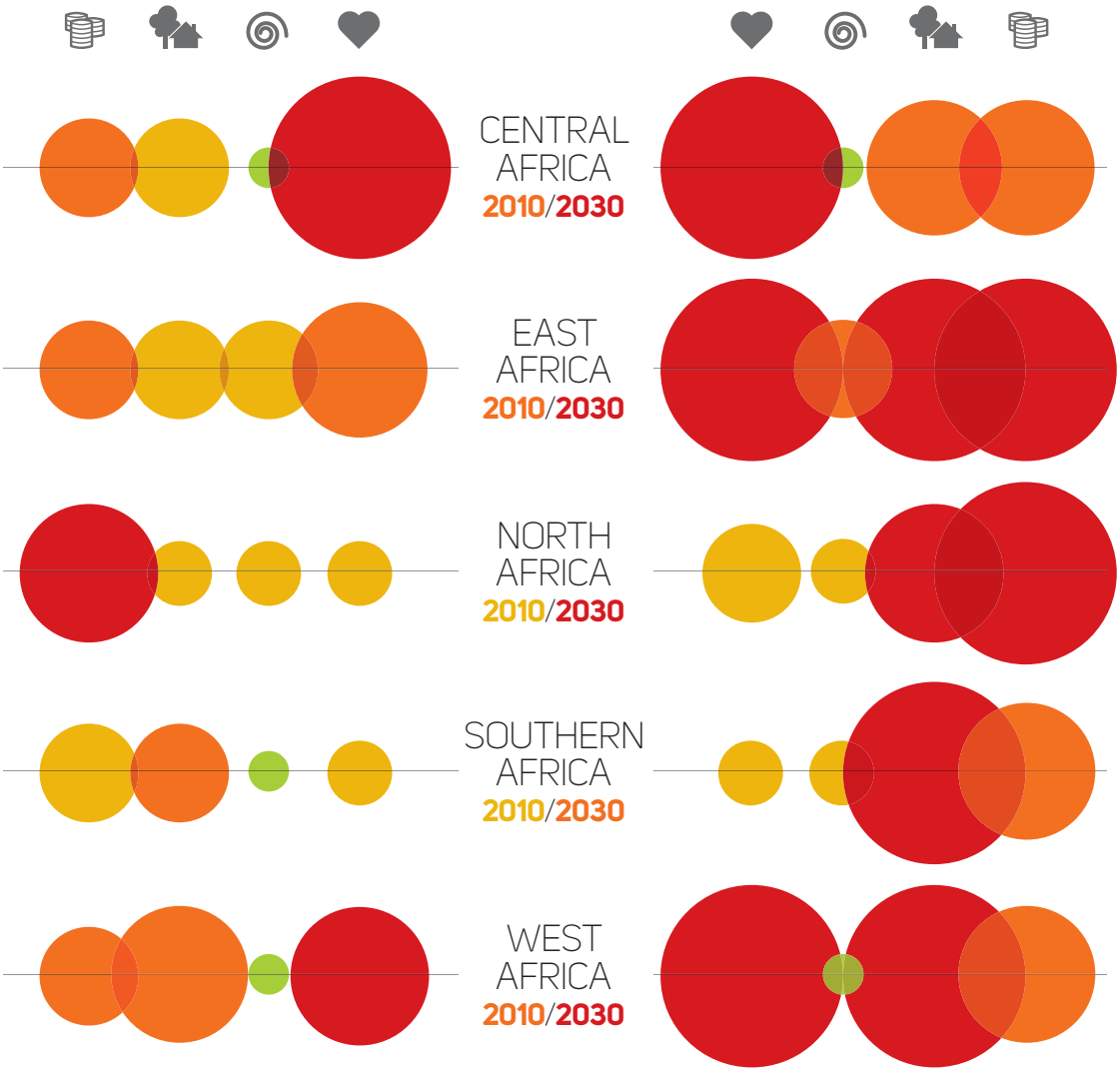

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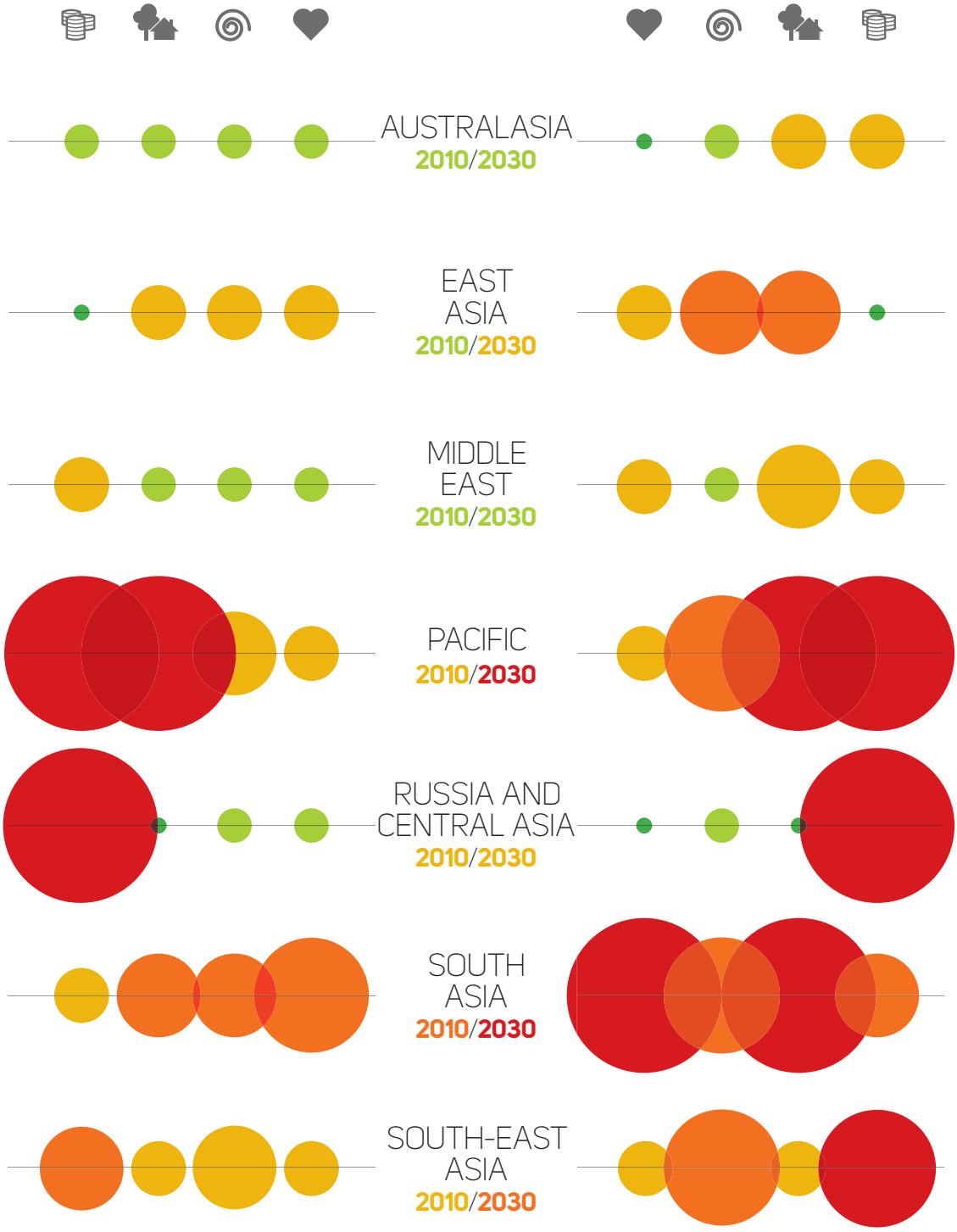

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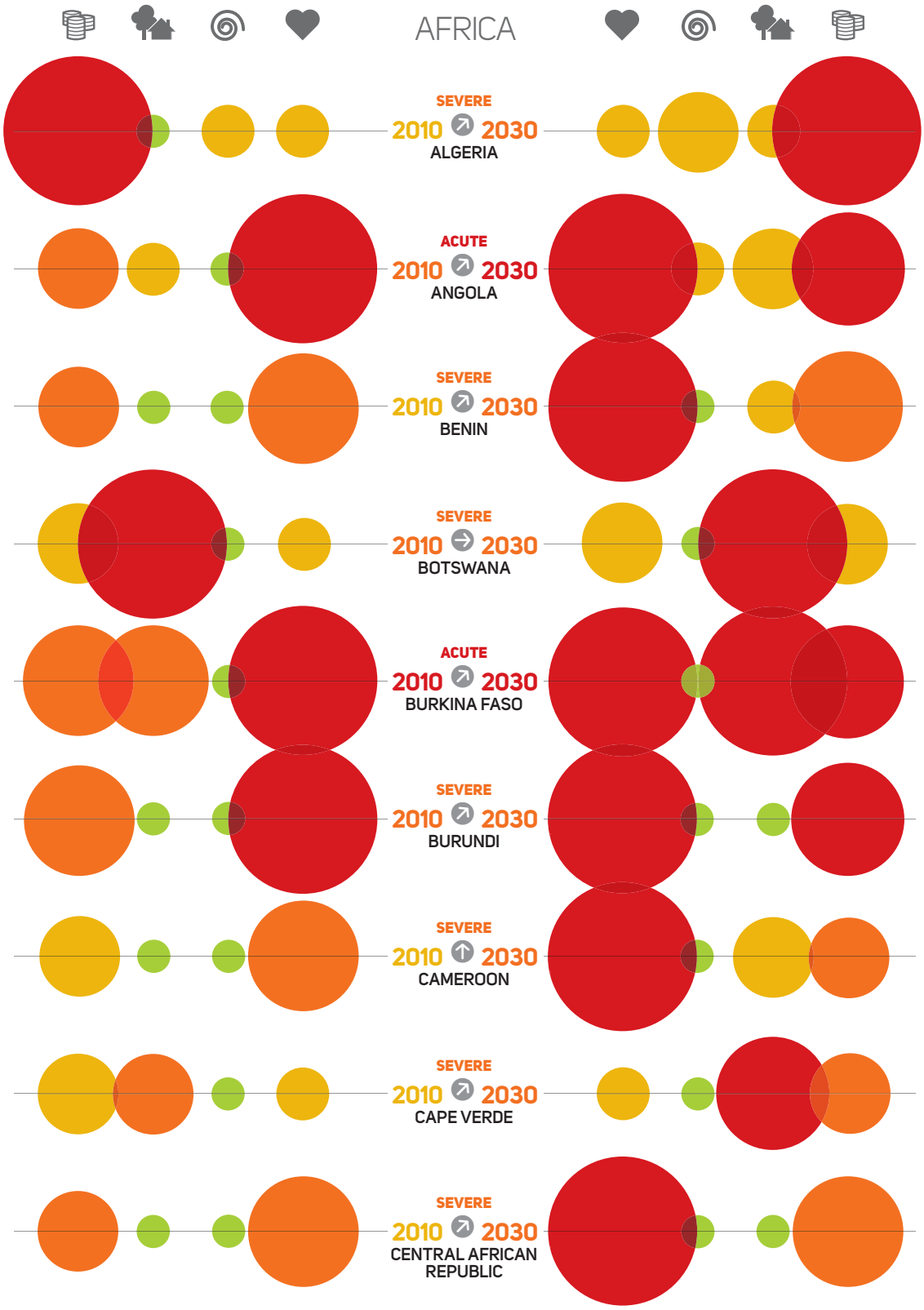

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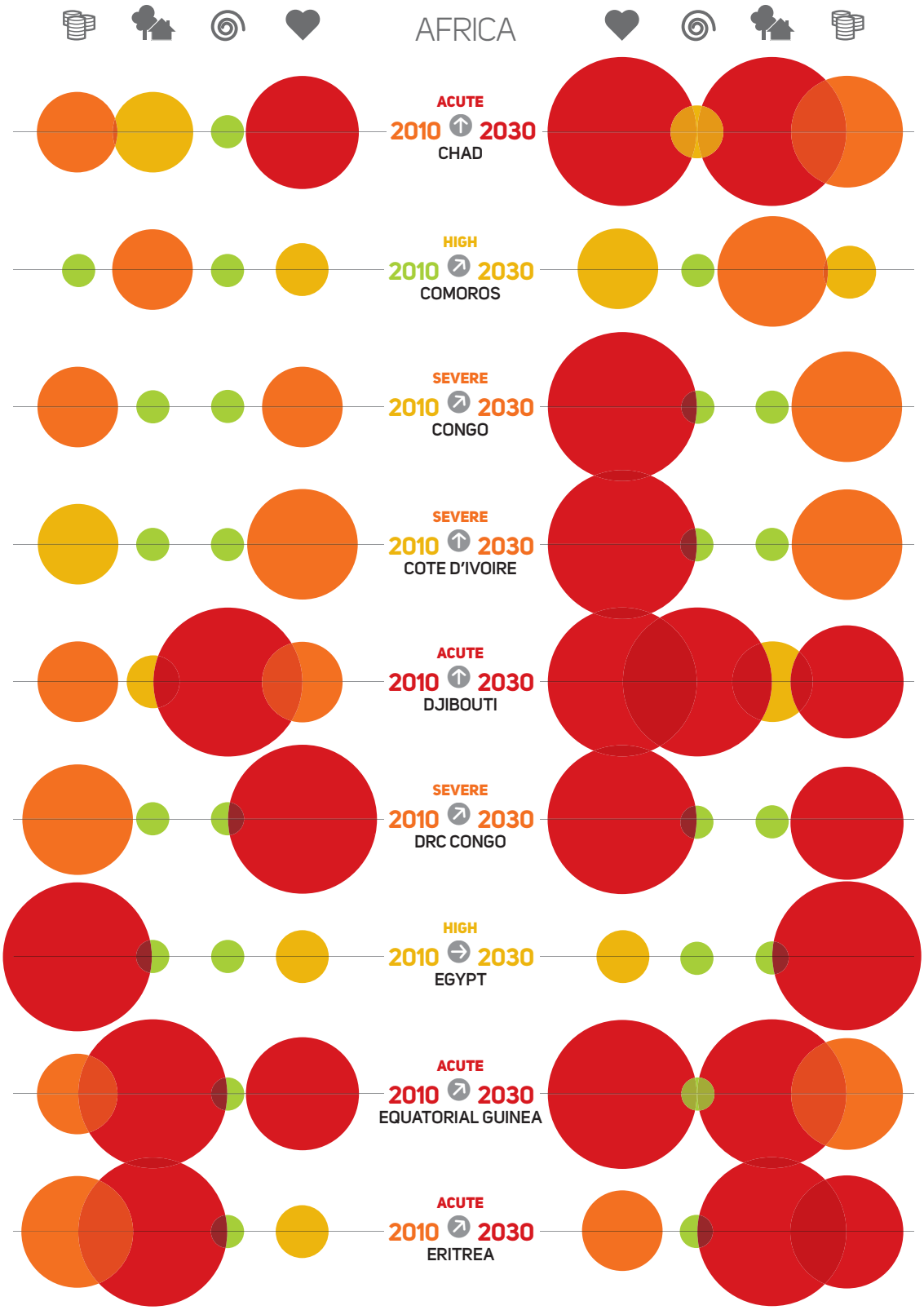

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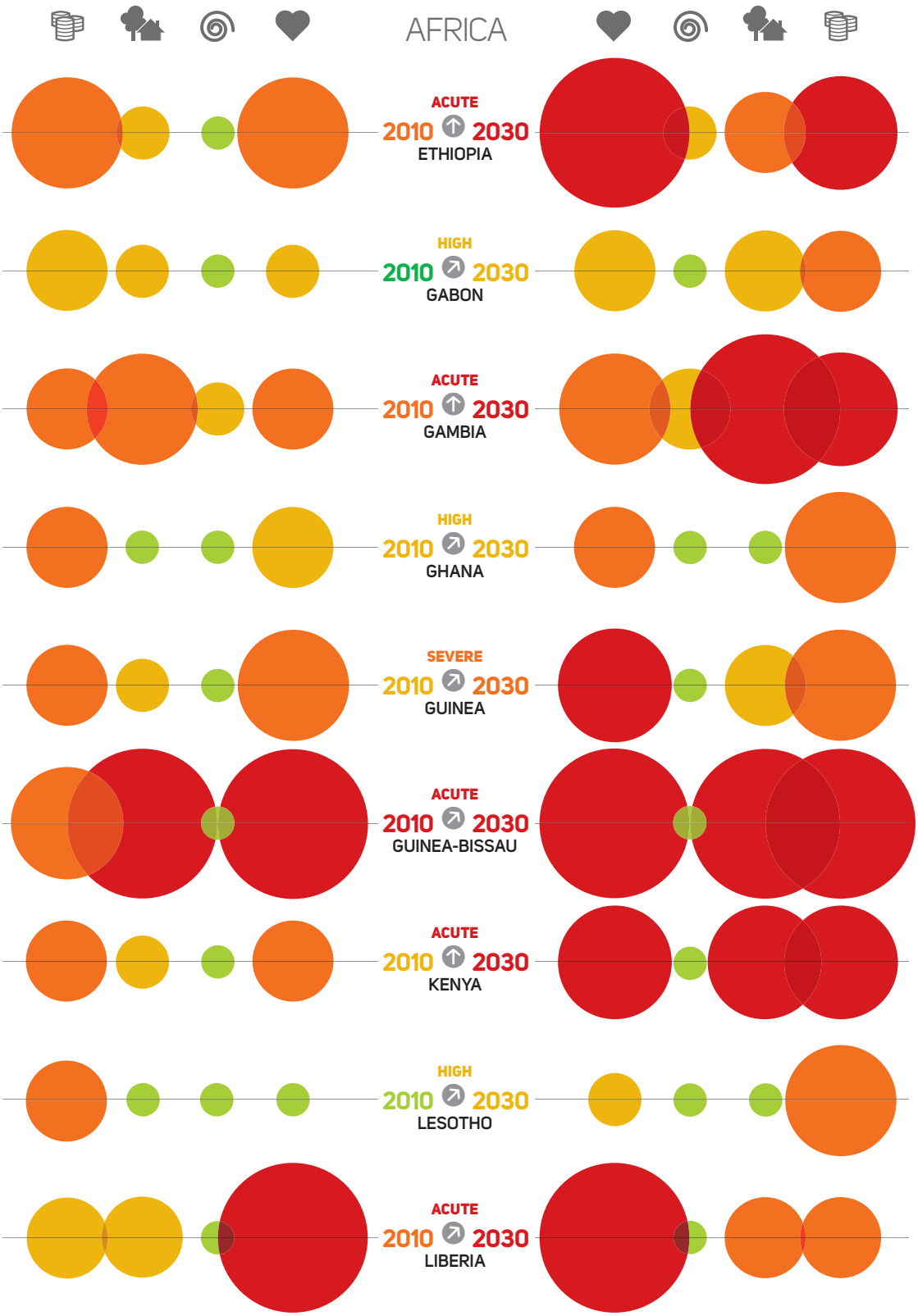

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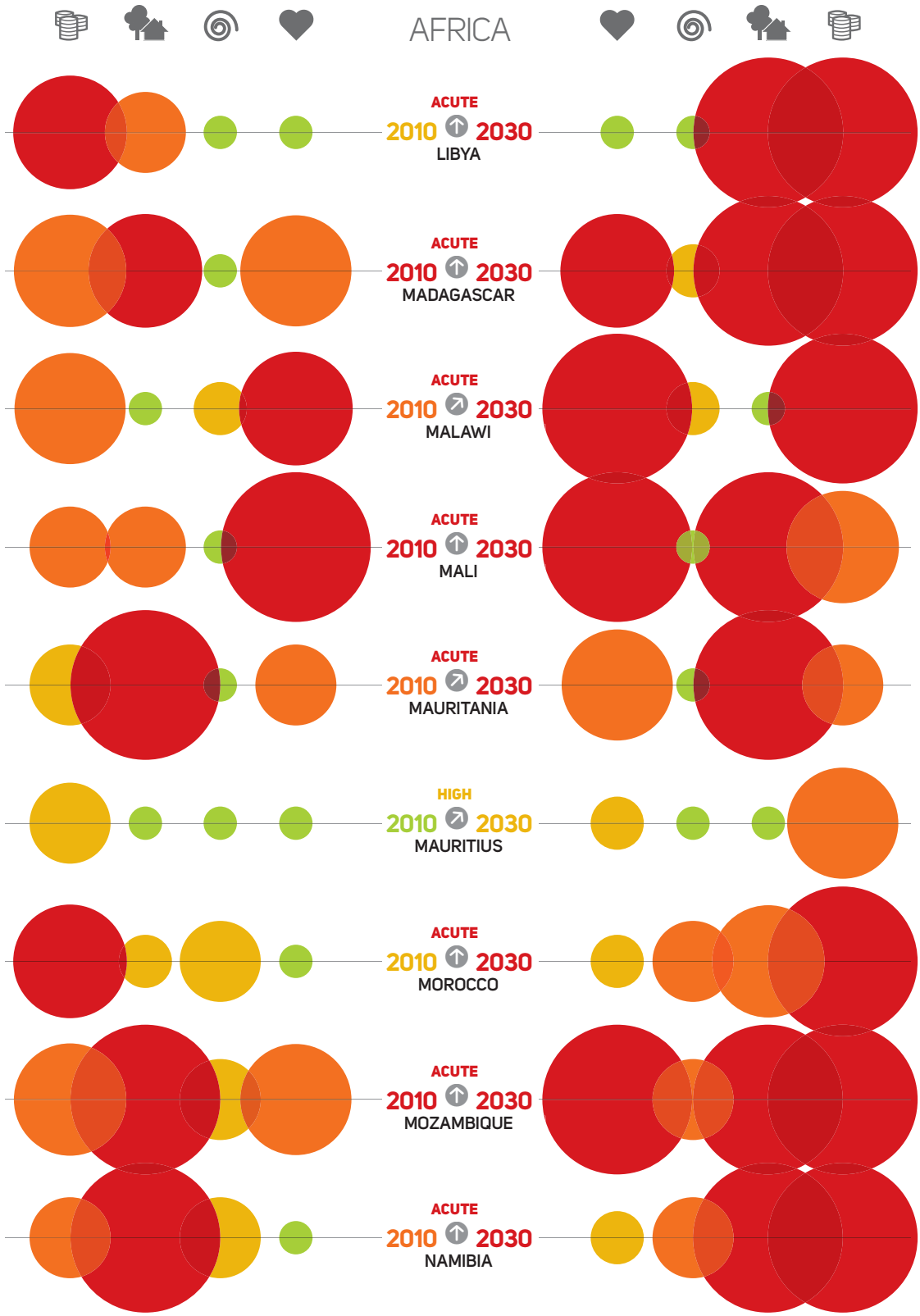

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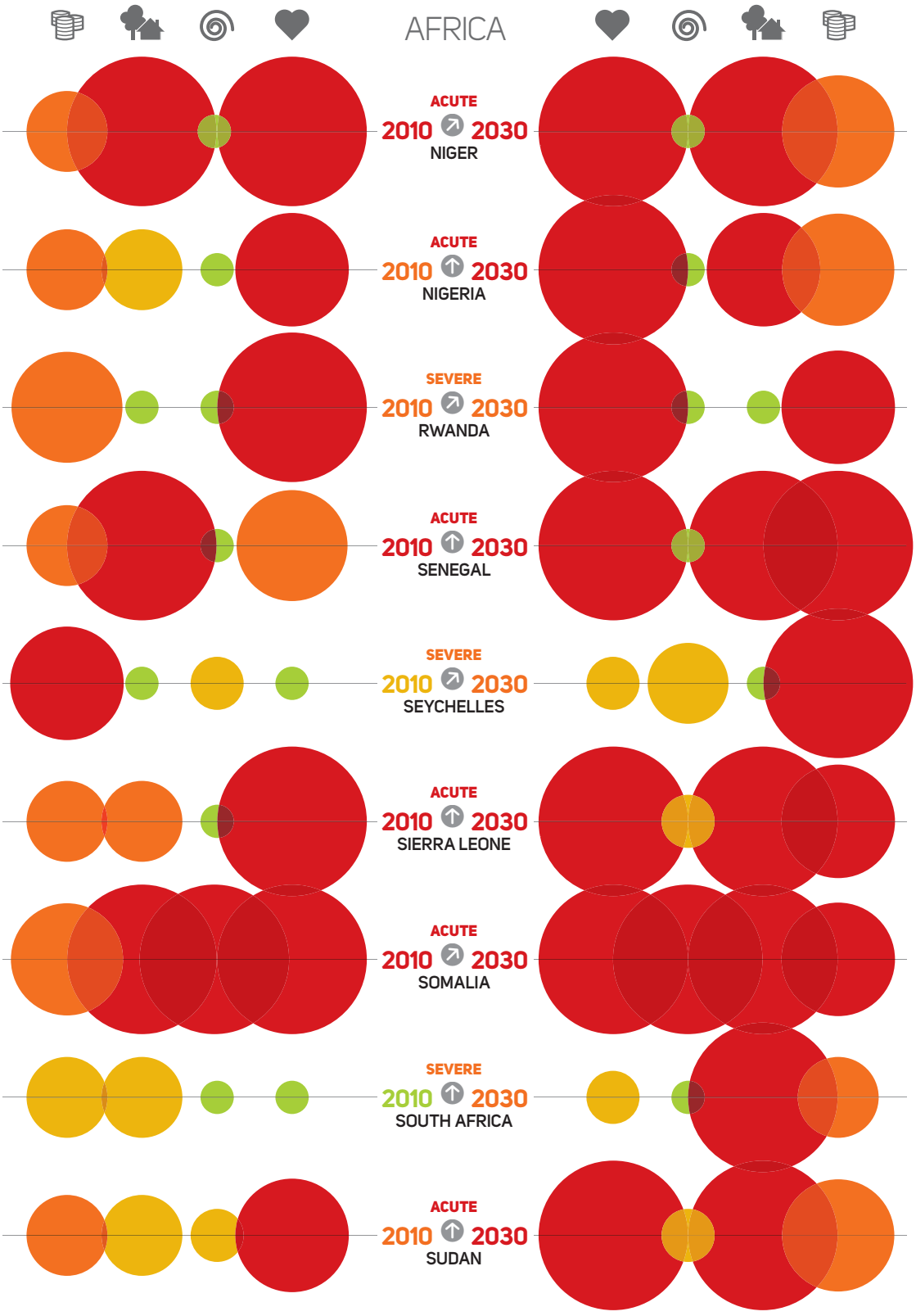

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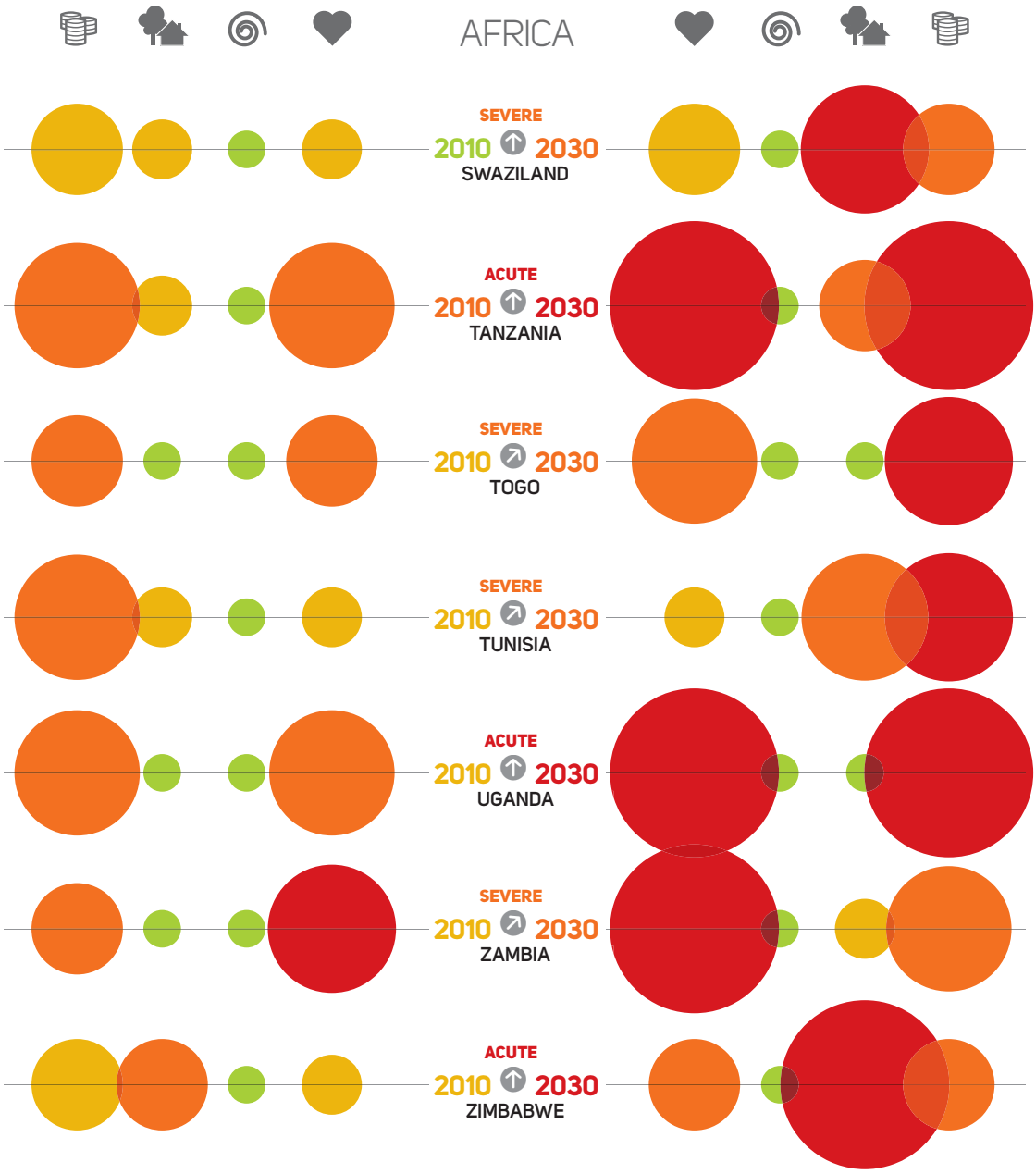

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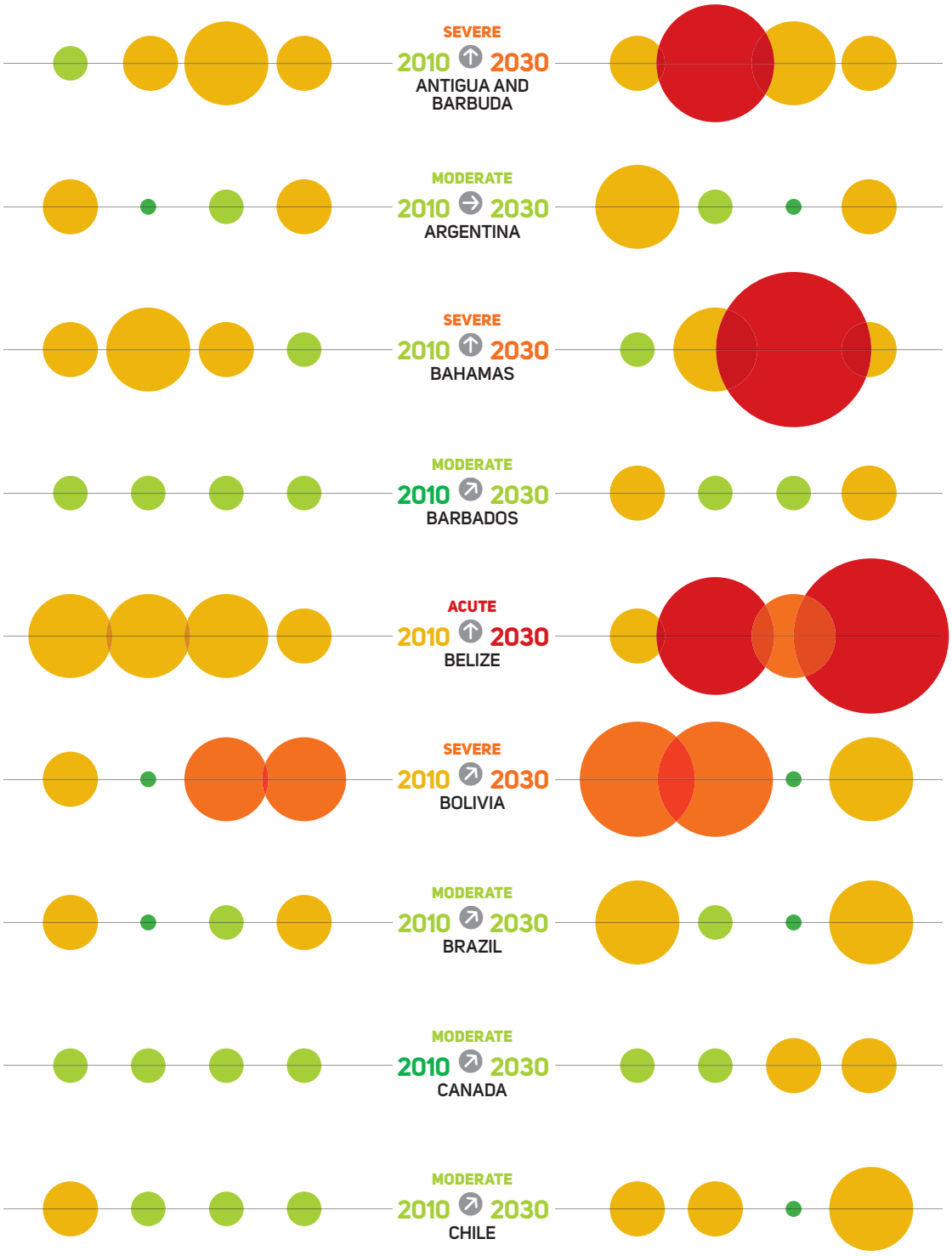

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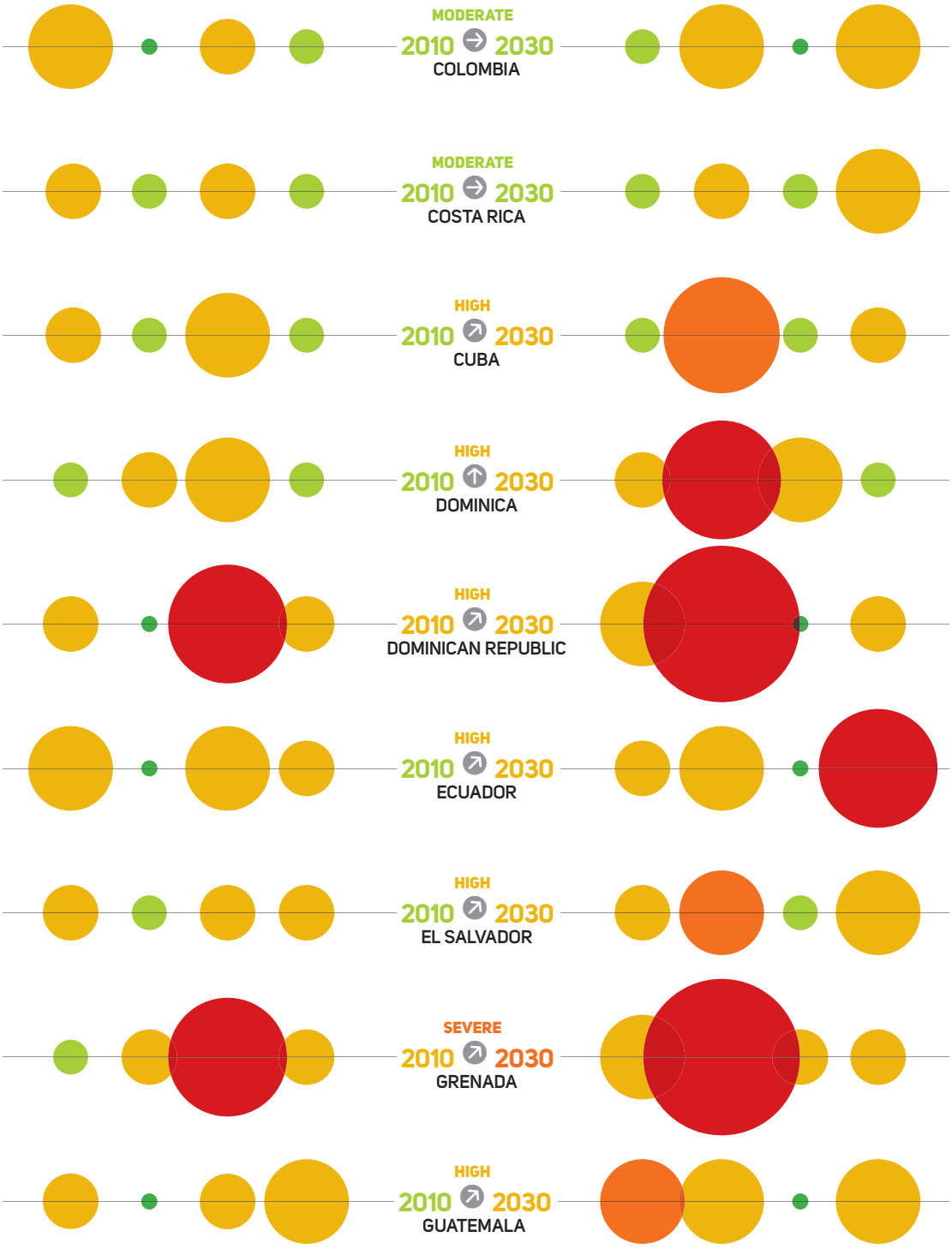

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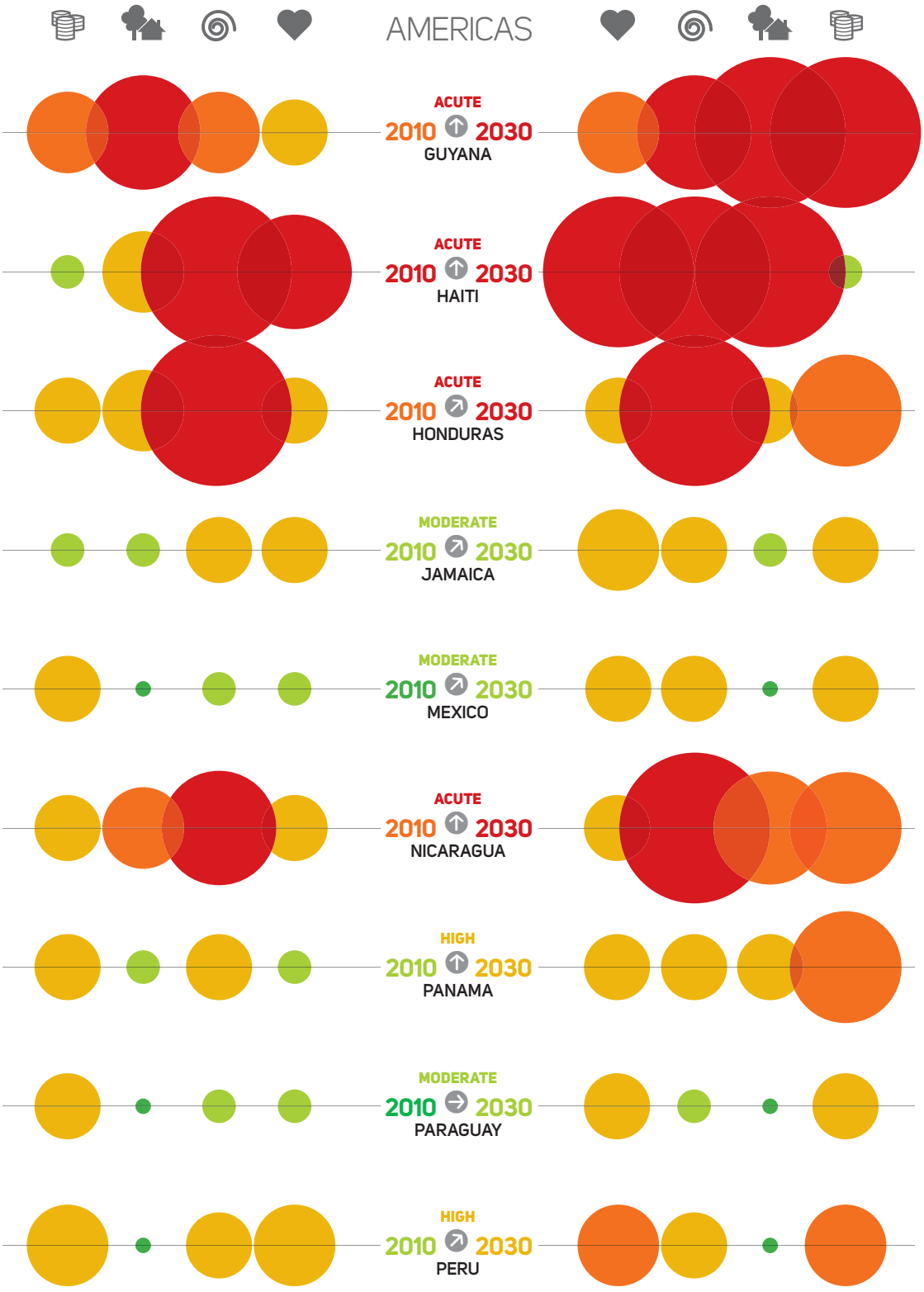

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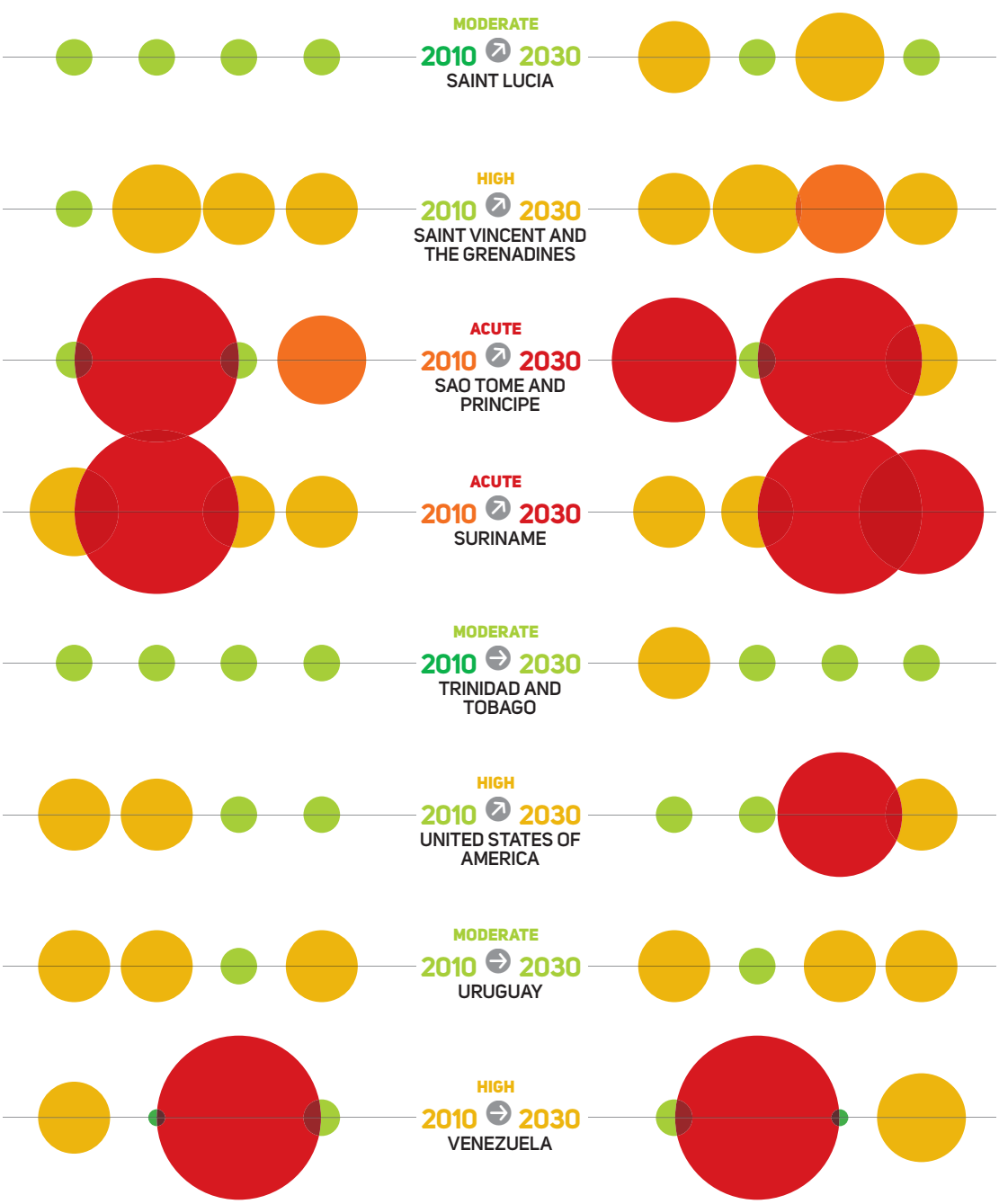

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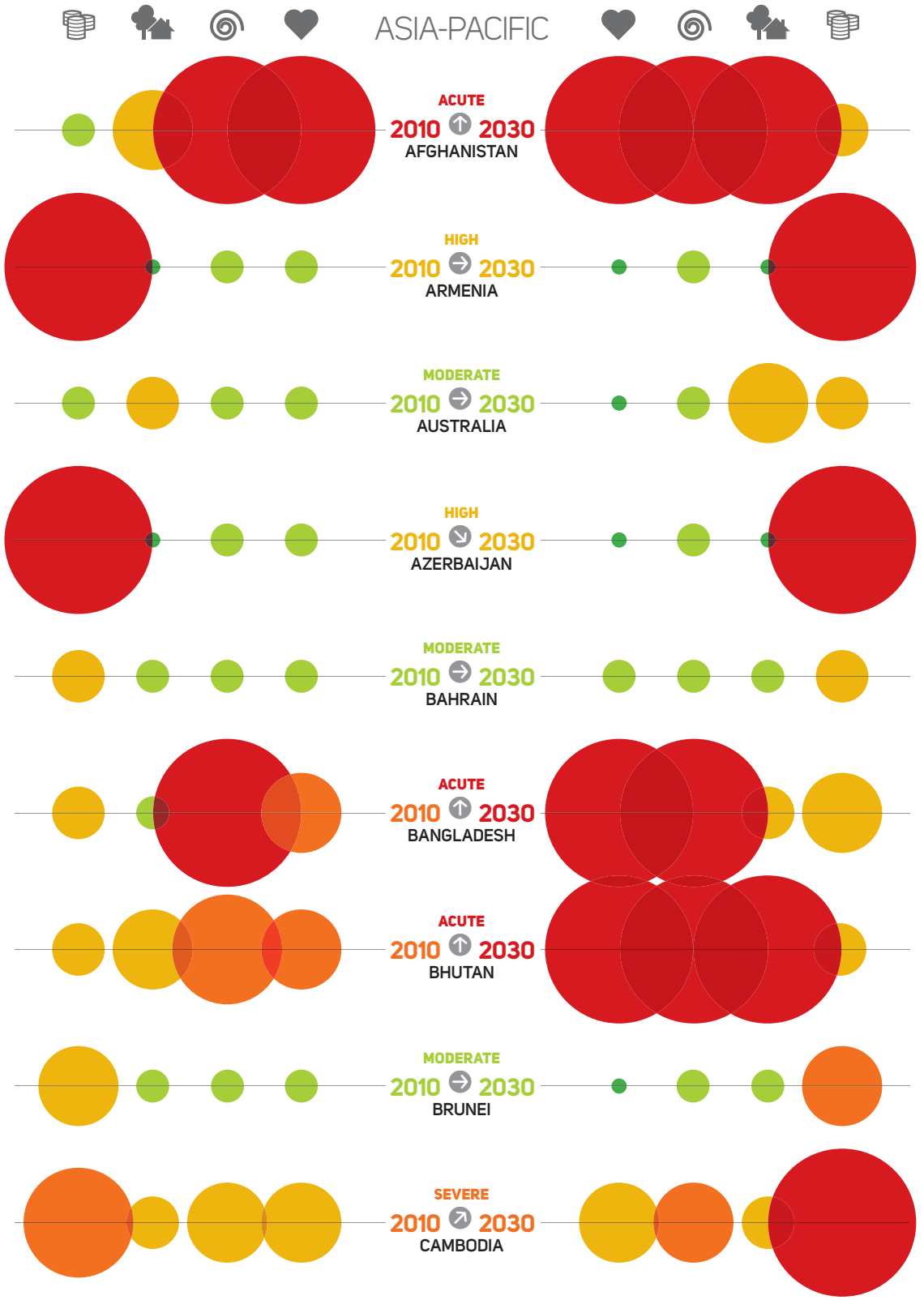

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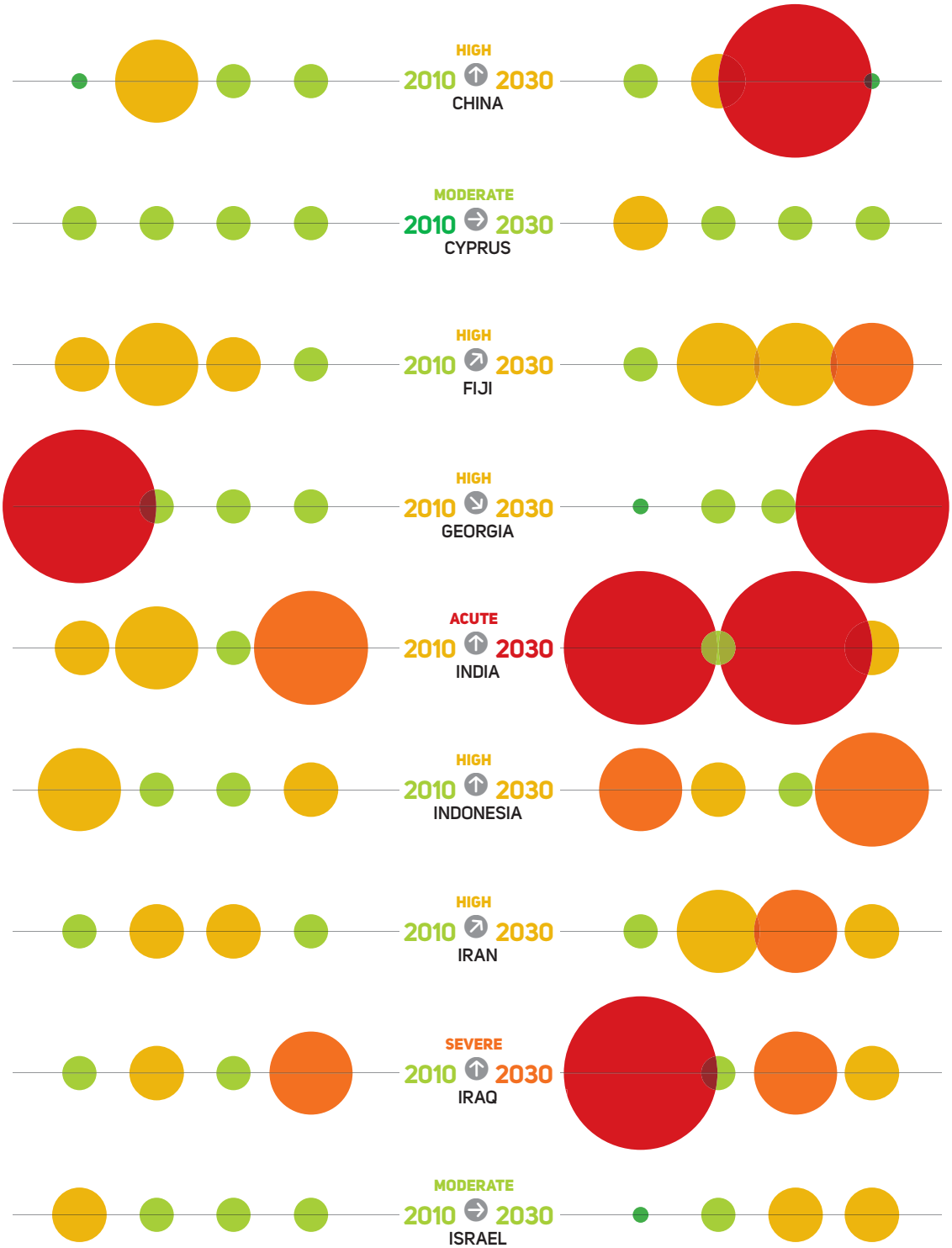

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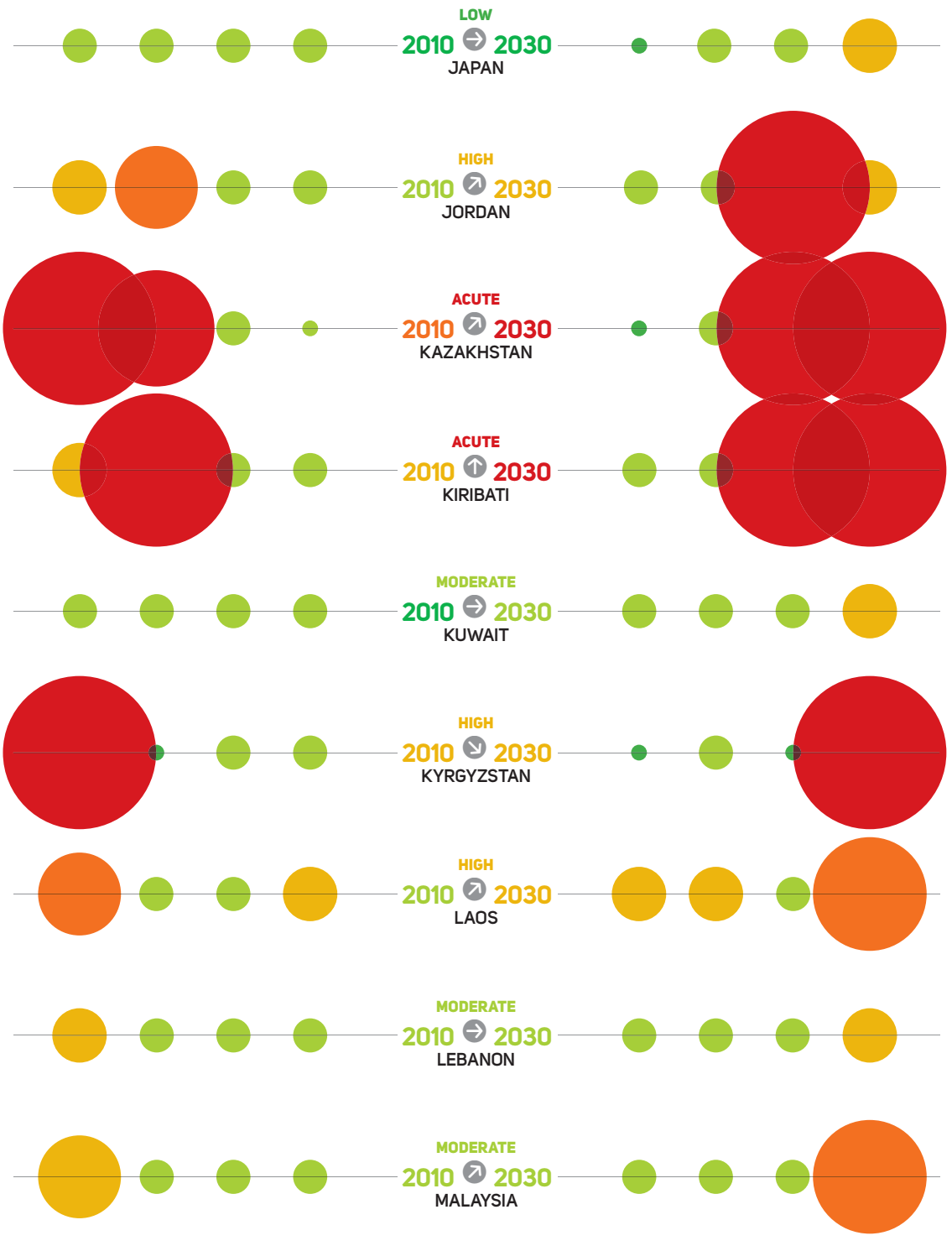

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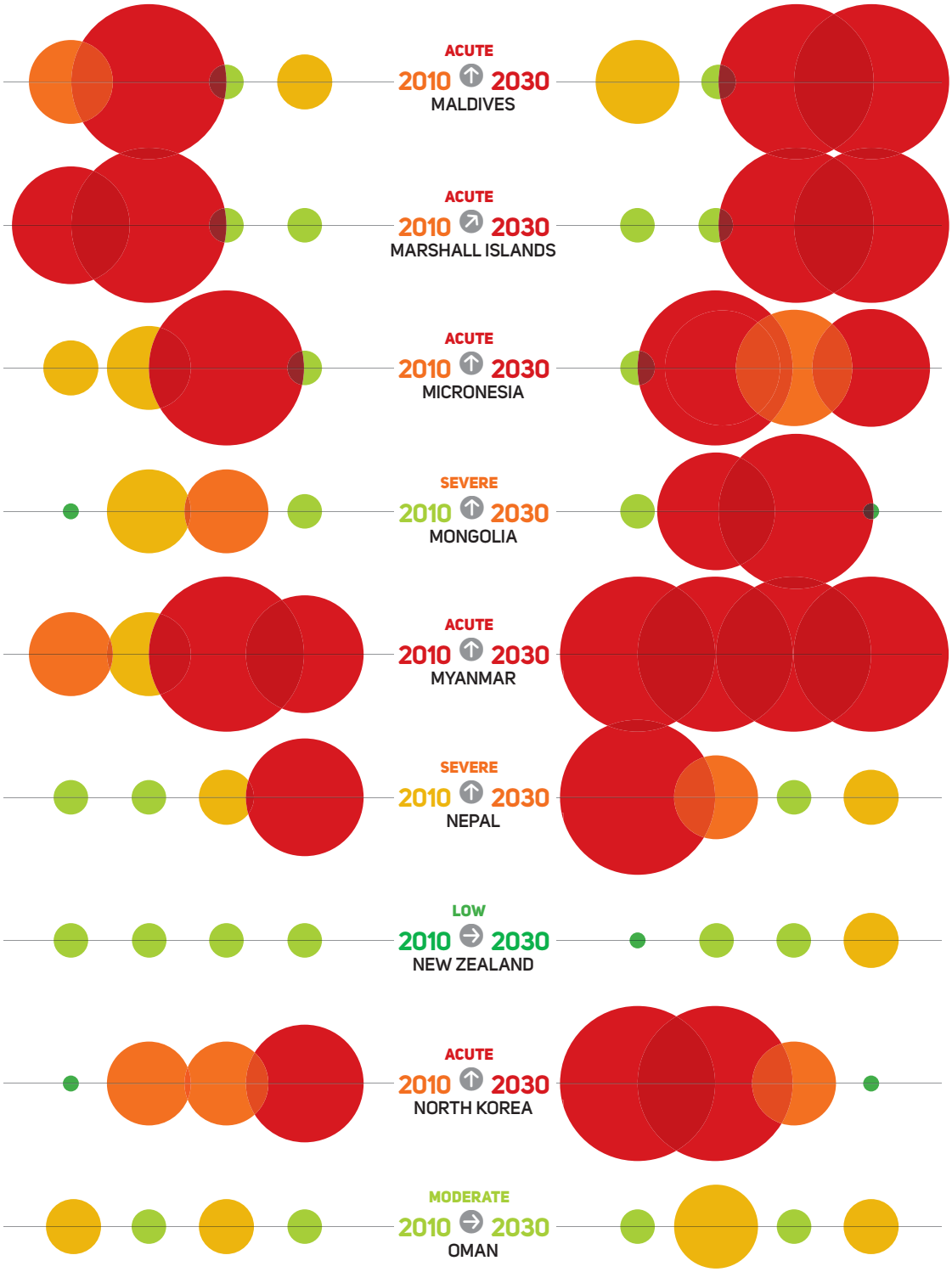

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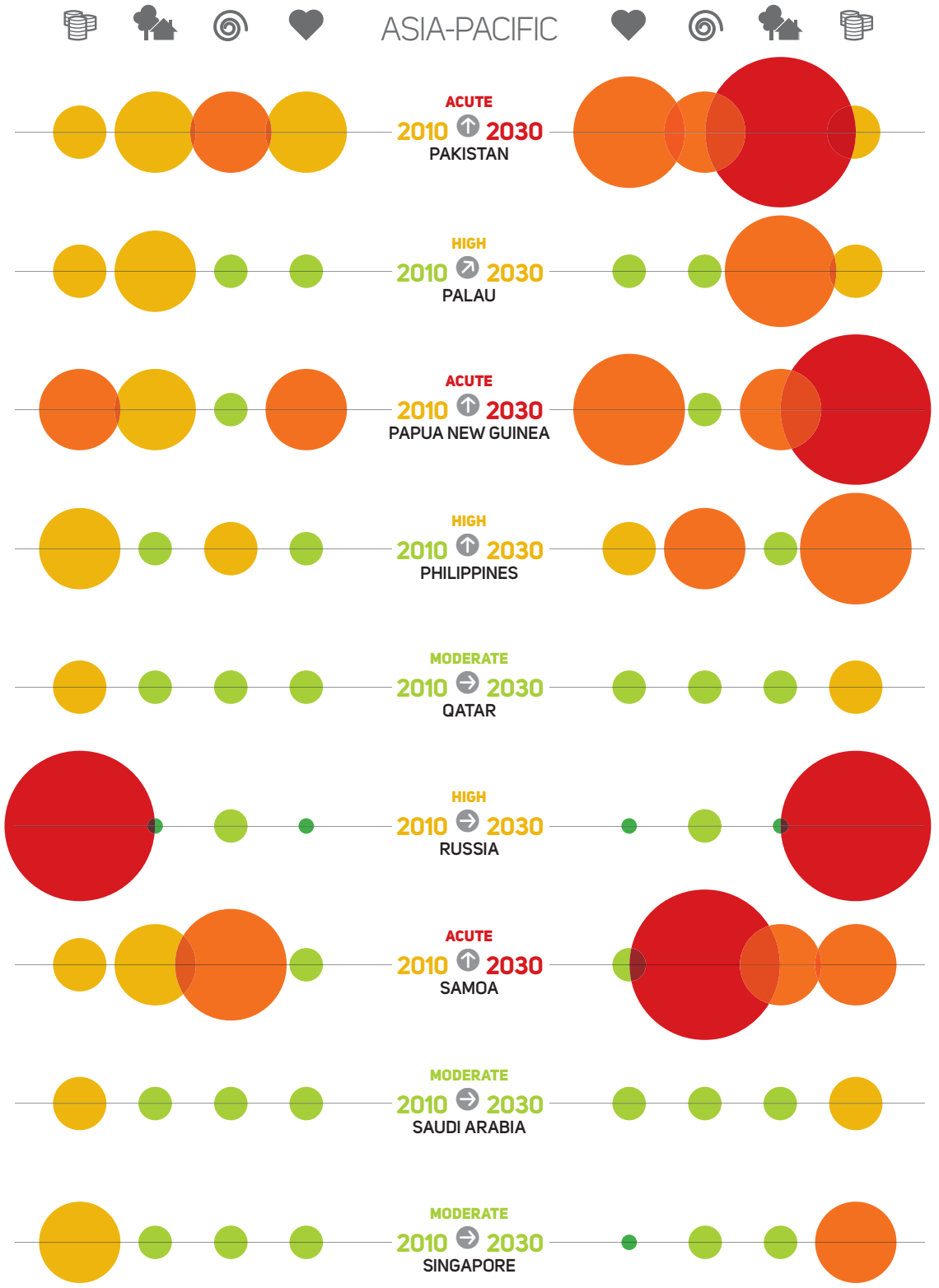

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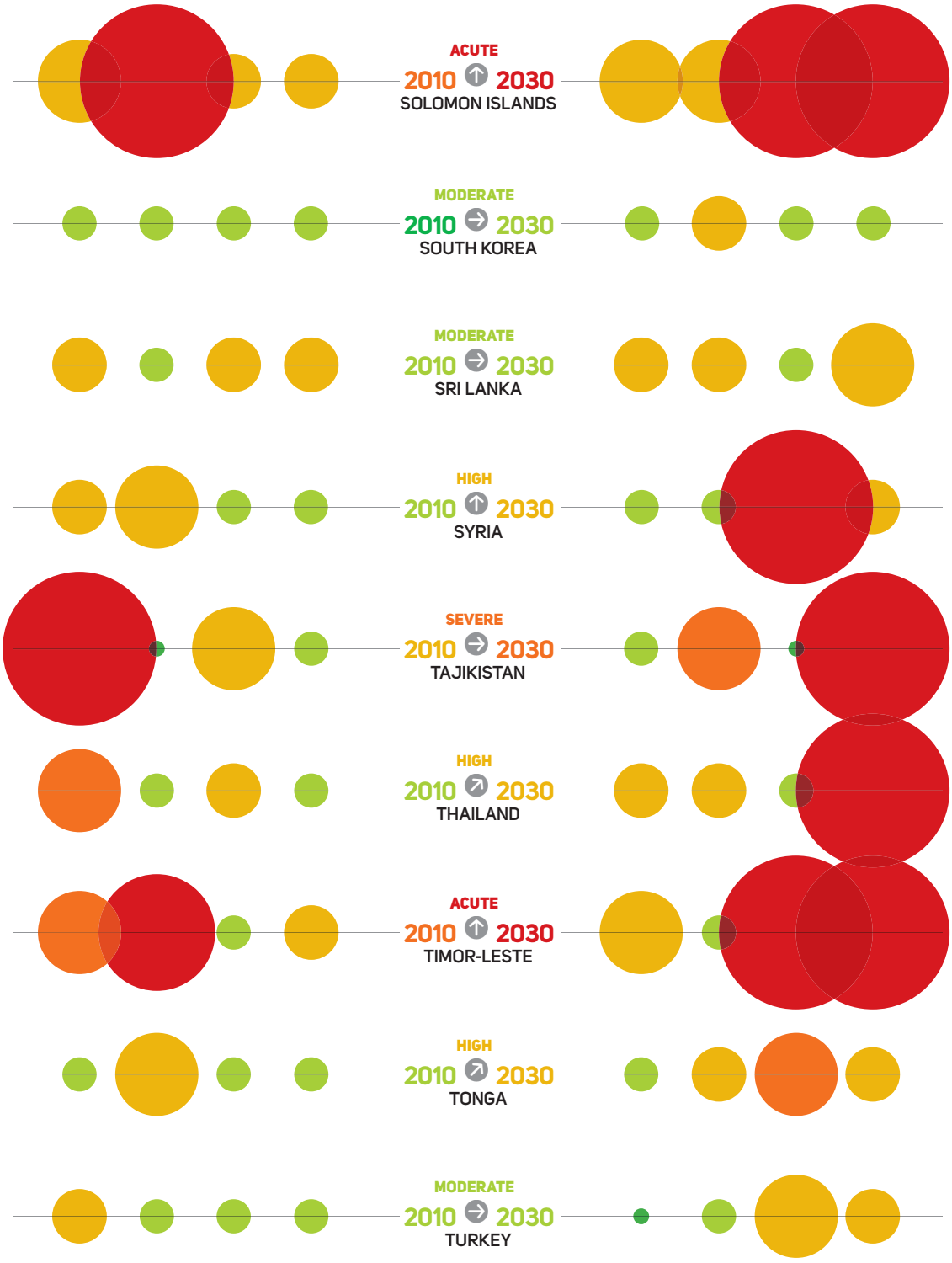

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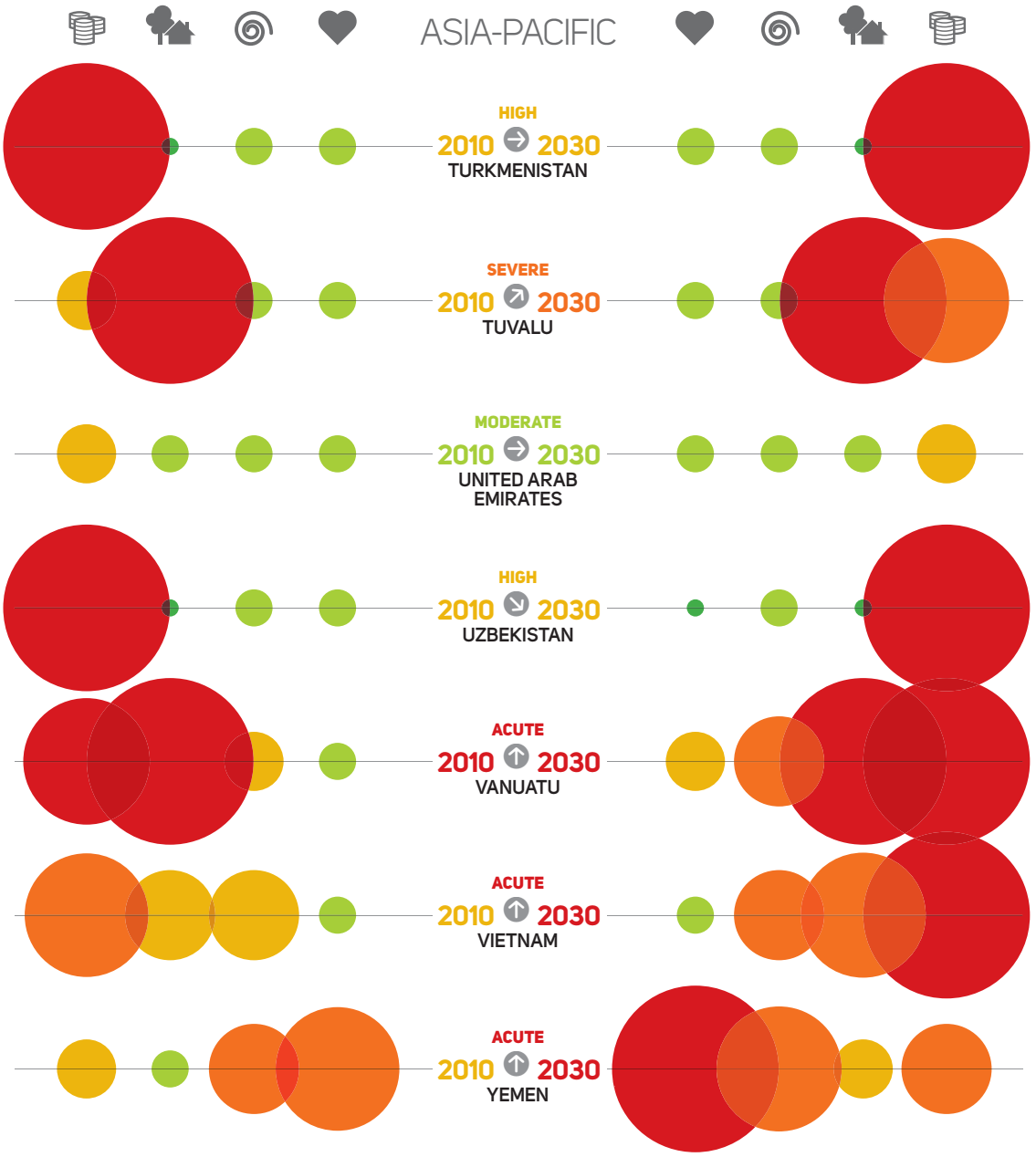

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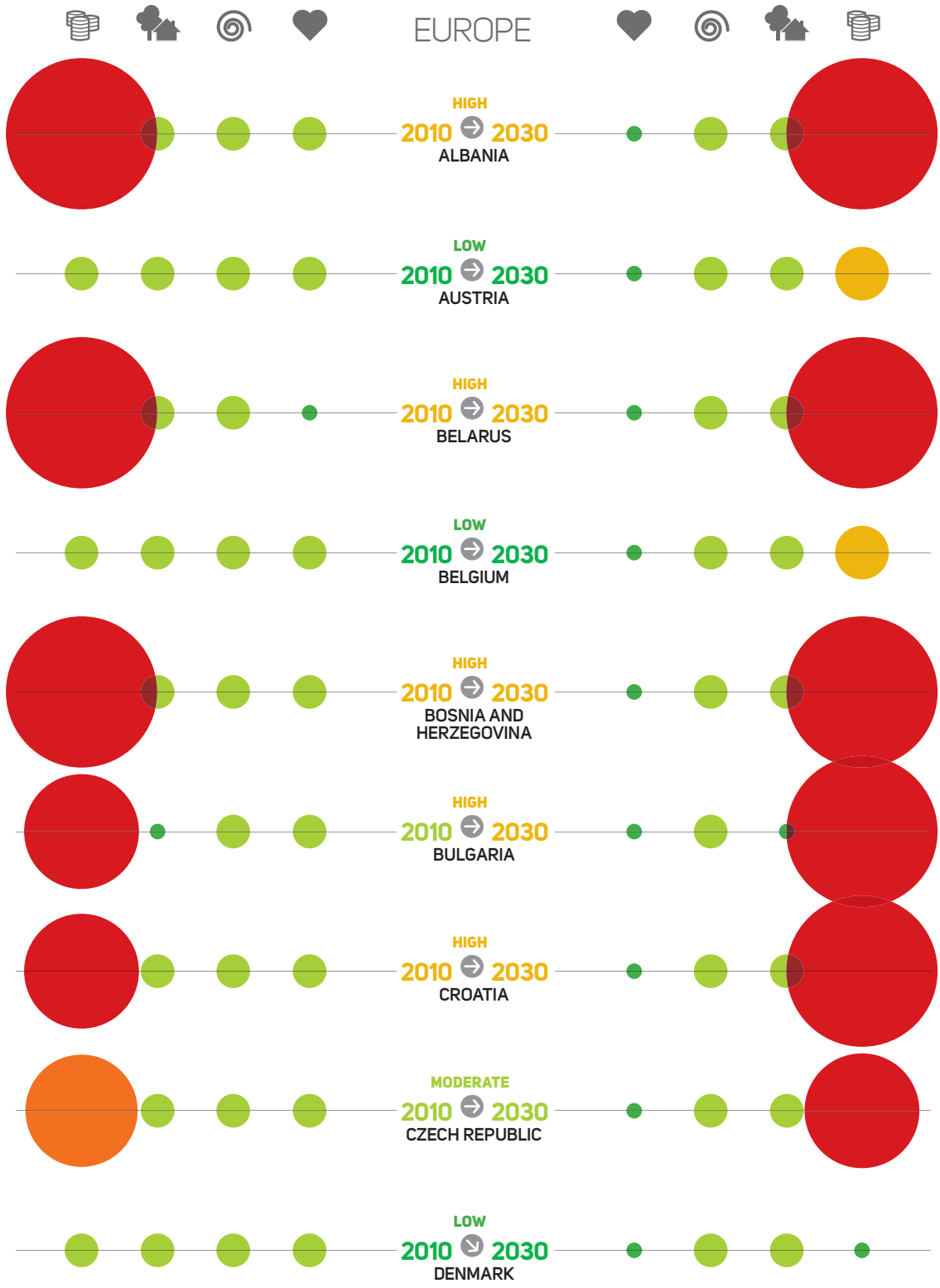

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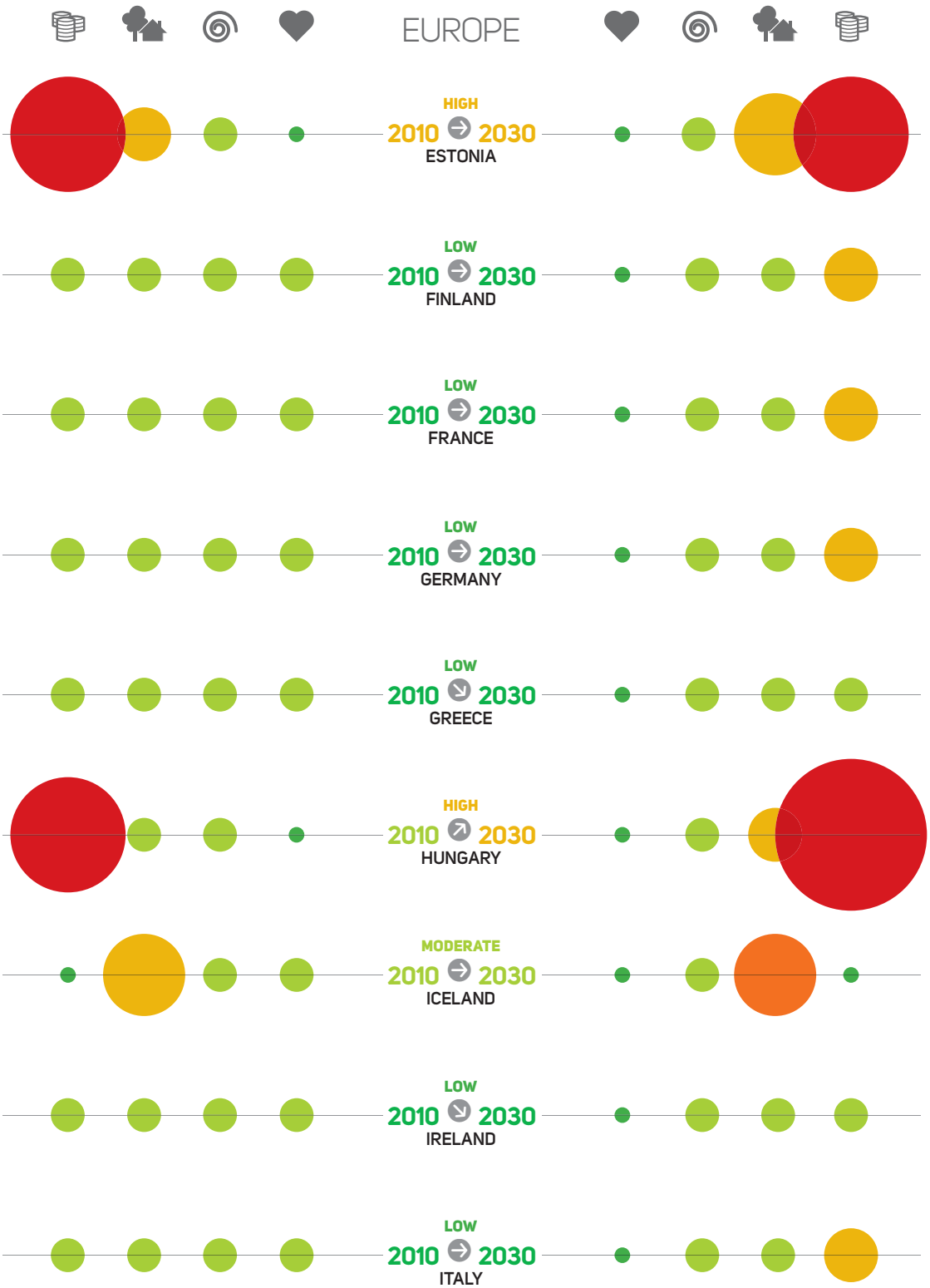

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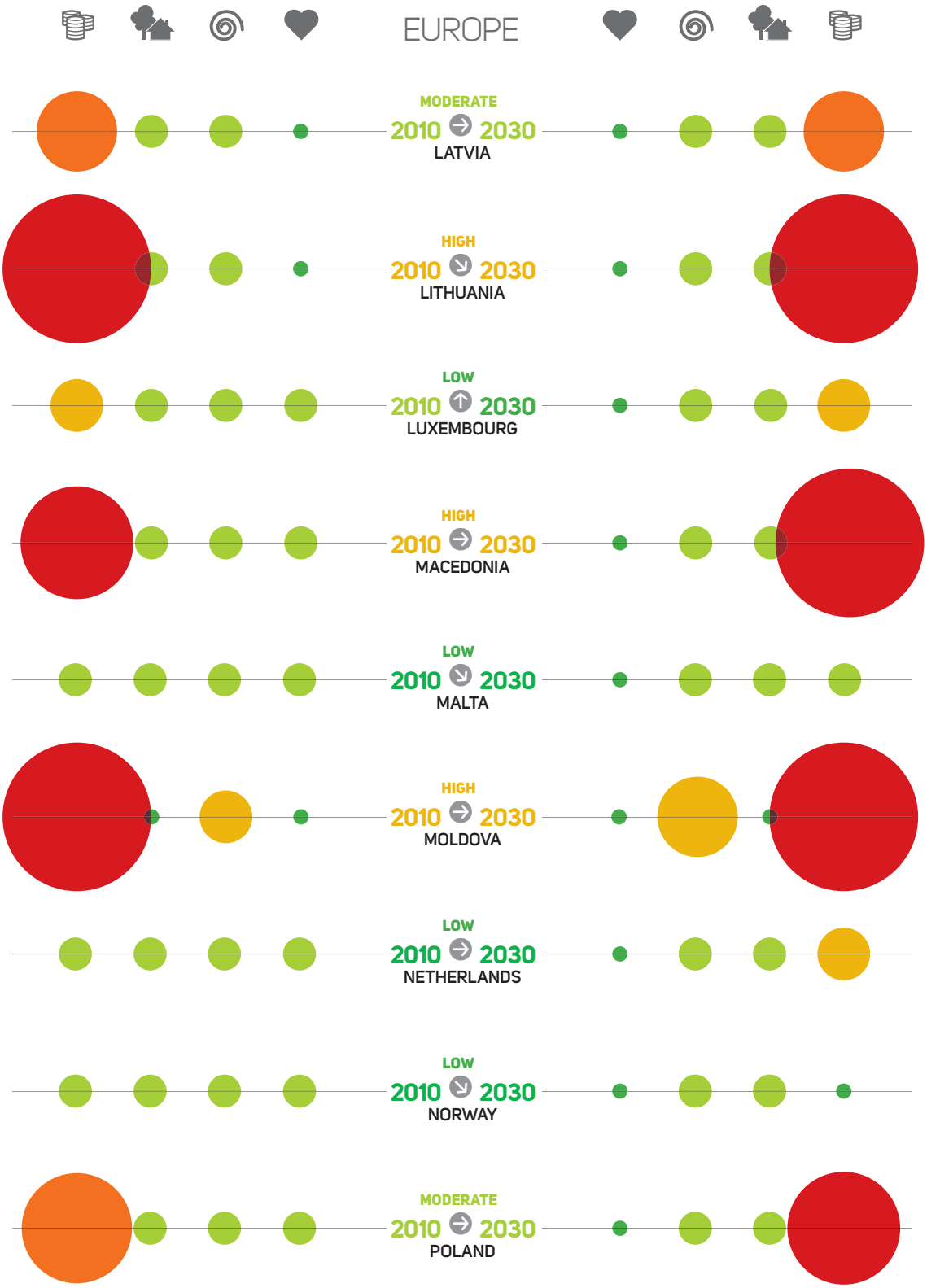
EUROPE



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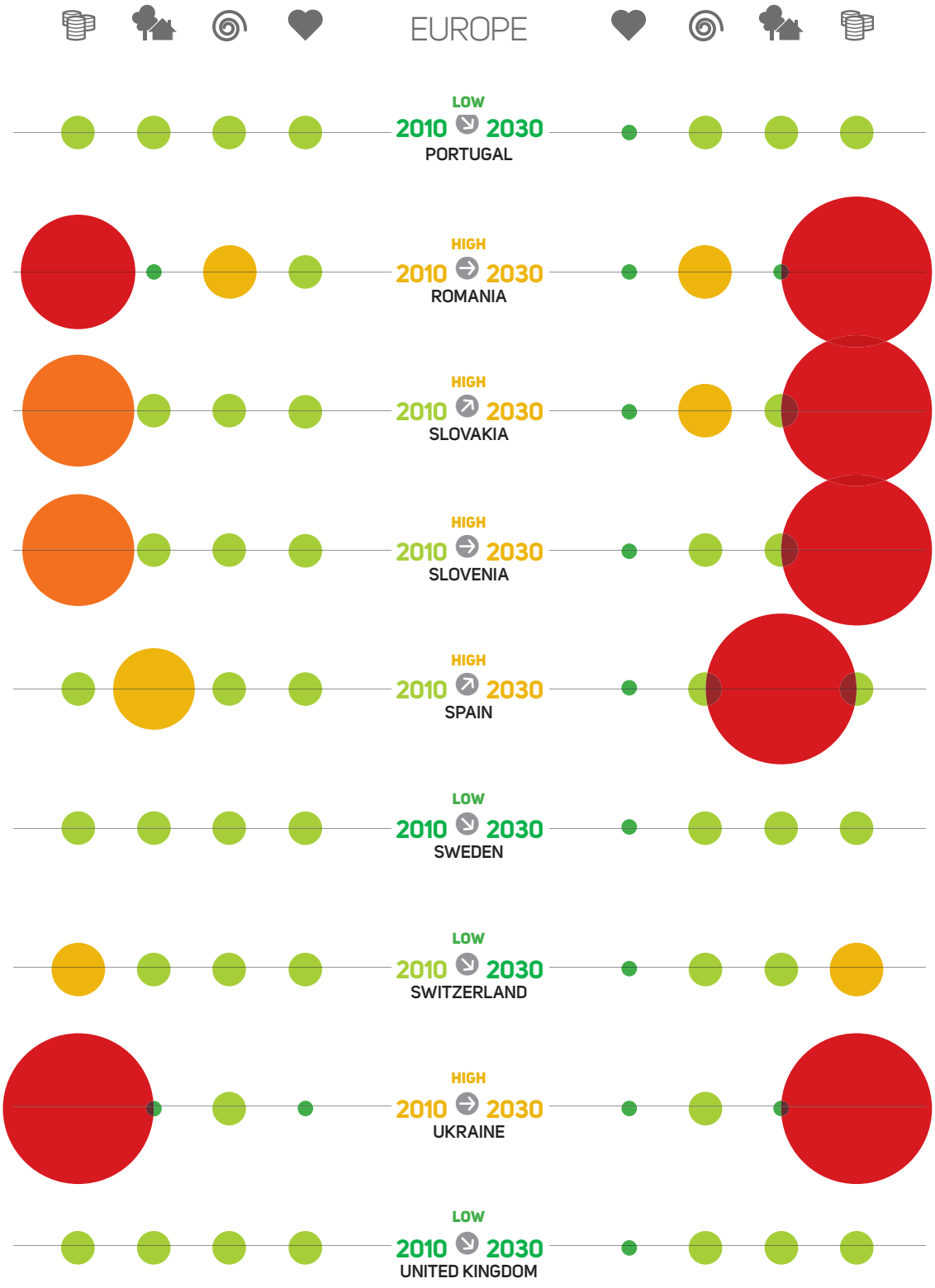

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WHAT IS THE MONITOR?

The Climate Vulnerability Monitor assesses the impact of climate change on 184 countries based on leading research. The impacts highlight where vulnerabilities to climate change lie. The Monitor measures effects across four main areas: Health Impact (deaths due to climate-sensitive diseases), Weather Disasters (deaths and damage caused by storms, floods, and wildfires), Habitat Loss (populations at risk to desertification and sea-level rise), and Economic Stress (industry and asset losses).

The Monitor combines the four main areas of impact and determines an overall factor of vulnerability, which is meant to be purely illustrative of the extent to which a given country is suffering from multiple climate stresses. Every country in the world thereby has its climate vulnerability profile assessed via the same set methodology. The Monitor recognizes five vulnerability levels, called "factors": Low, Moderate, High, Severe, and Acute. Factors give an indication of how vulnerable a country is to the effects of climate change in each of the impact areas, and overall. The Monitor provides factors overall and for today, in the year 2010, and in the near future, for the year 2030.

HOW THE MONITOR WORKS

DESIGNED TO ISOLATE KEY IMPACTS

Most existing indices of climate vulnerability employ some combination of socio-economic capacity set against meteorological and/or hydrological change.[9] The Monitor does not focus directly on capacity, nor in most cases directly on climate variables, since these in themselves do not pinpoint any impacts as they might occur, such as mortality linked to climate-sensitive diseases, or desertification aggravated by local climate shifts. So they have limited usefulness for targeting actual responses. The Monitor was developed to understand and highlight climate vulnerability in a way that could aid in the design of actions to avert harm to communities.

The Monitor identified four main types of impacts across the different areas of vulnerability that it assesses. These areas were chosen over others for various reasons. One, since each represents a distinct set of stresses that can be isolated from one another. A country like Rwanda, for instance, could have serious health impacts but suffer no marked desertification or sea-level rise impact, and it is not affected by tropical cyclones or major floods due to glacial melt. Two, since for each of the different impact areas, we also outline distinct types of measures that can be taken to reduce the negative effects. And three, because each of the main elements of the four different impact areas included data sets of globally available information and in many cases models that already existed estimating the relationship between the underlying variable and climate change. As a result though, the Monitor is not fully comprehensive in that certain impacts are excluded. Some of the measurements are also restricted in the information they provide -- such as mortality only in extreme weather as opposed to numbers of people affected or displaced -- so impact estimates should be treated as indicators of a wider problem.

Many countries also register severe impacts across a range of categories. Eritrea for instance, suffers both sea-level rise impacts and desertification and is highly vulnerable to the health impacts of climate change. These are multiple-stress countries, where several impacts are brought to bear in one place, seriously compounding one another. We have included an overall vulnerability factor for each country, since it captures a sense of these multiple stresses. However, the overall factor has been compiled with an even weighting from across the four impact areas. Fair arguments could well be made in favour of, for example, a much higher weighting for impact areas where human lives are at stake. Elsewhere, countries with very high vulnerability in just one impact area may feel de-prioritized, or that the rigid split is prescriptive in terms of existing national strategies. As such, the overall vulnerability factor should not be used for planning purposes or to prioritize responses. Responses need to focus on tackling vulnerability as highlighted in the individual impact areas. The overall vulnerability level referred to in the report is based on 2030, since while information

THE MONITOR WAS DEVELOPED TO UNDERSTAND AND HIGHLIGHT CLIMATE VULNERABILITY IN A WAY THAT COULD AID IN THE DESIGN OF ACTIONS TO AVERT HARM TO COMMUNITIES

is estimated for 2010, it in many cases relies on base information several years old. Furthermore, 2030 impacts are inevitable without remedial actions due to the unstoppable warming in the climate over the next 20 years.

In each of the four impact areas, we have assigned a "climate effect" to a given region, which estimates the role of climate change in driving diverse impacts. The climate effect reacts to existing societal characteristics, such as widespread climate-sensitive diseases like malaria, frequent large-scale storm or flood damage, or comparatively large agricultural sectors. Underlying vulnerabilities that react to climate change vary from country to country, and with them vulnerability to climate change itself. The most recent expertise and models provide indications for these reactions in different parts of the world. Nevertheless, where there is a higher concentration of the types of vulnerabilities that are most sensitive to climate change, we have rated vulnerability higher.

CLIMATE VULNERABILITY MONITOR ARCHITECTURE

	HEALTH IMPACT	WEATHER DISASTERS	HABITAT LOSS		ECONOMIC STRESS	
			DESERTIFICATION	SEA-LEVEL RISE	LAND	MARINE
UNDERLYING VULNERABILITY	Existing Levels of Climate-Sensitive Diseases	Prevalence of Historical Casualties and Damage	Scale of Populations in Arid Regions	Scale of Vulnerable Shoreline and Coastal Communities	Size of Agriculture Sector, Sensitivity of Water Resources, Vulnerable Species/Non-Human Habitats	Size of Fisheries Sector, Coral Reef Abundance
MAIN CLIMATE RISKS	Heat and Flooding	Floods, Storms, and Wildfires	Heat, Rainfall Loss, Drought, Winds	Ocean Water Levels, Salt Intrusion	Heat, Rainfall Loss, Drought, Mid-Latitudes	Ocean Warming and Acidity
INDICATOR USED	Additional Deaths from Key Climate-Sensitive Diseases	Additional Deaths and Damage Costs from Floods, Storms, and Wildfires	Additional Populations at Risk	Cost of Protection and Land Loss	Sector/Industry and Asset Losses	Sector /Industry Losses
DATA SOURCES	World Health Organization (WHO)	CRED EM-DAT and Munich Re NatCatService	PLACE II	DIVA	FUND	World Resources Institute
MODELS	WHO HadCM2 global	WHO and Estimated*	IMAGE 2.2	DIVA	FUND2.8n	Estimated*
EMISSION SCENARIO	s750	Hypothetical* and s750	Average of All IMAGE Models	A1F1	EMF14 (IS92a/ IS92f)	SRES A1B
KEY VULNERABILITY DRIVERS	Human Development Gender Development Governance Systems Public Services Resources Management/Stocks (Water, Land, Marine) Insurance Coverage Infrastructure Placement/Design			**KEY EXPOSURE DRIVERS**	Demographics Geography Existing Climate Conditions	

*Urgent requirement for scientific quantification of changes taking place

To establish the scale of societal characteristics across countries, the Monitor very simply looks from country to country at historical records or satellite observations of phenomenon we know are influenced by climate change. The historical record is assumed to provide a good indicator of the ongoing state of underlying climate-sensitive vulnerabilities in a given country. These include coastal areas exposed to sea-level rise or lands prone to desertification. Also included are communities suffering from climate-sensitive infectious diseases, damages registered as a result of extreme weather, and key economic sectors or natural resources knowingly affected by changes in climatic conditions, such as agriculture, fisheries, and water supplies.

CURRENT AND SHORT-TERM VULNERABILITY: A NEW PERSPECTIVE

The Monitor assesses vulnerability overall and for 2010 and 2030, providing an idea of what responses are needed today and how quickly they will have to expand in the coming years. Most existing climate vulnerability assessments have been carried out with a longer-term focus. Countries highly vulnerable in 2050, 2080, or 2100 will only register as vulnerable in the Monitor if they are also

expected to be exposed to climate shocks in the very near term. Since many countries have already begun to familiarize themselves with their own vulnerabilities on the basis of longer time scales, they may well be surprised when viewing that vulnerability on a much shorter time horizon. Some parts of Africa and the Americas, for example, may benefit from increased rainfall in the short term.[10] In other instances, countries that would have high vulnerability at the end of the twenty-first century are not the same as those countries with a high vulnerability today. Sea-level rise, for instance, is now slightly more than 3mm, or a fraction of an inch every year. Over 20 years, that would amount to about 7cm or 3 inches. This compares to worst scenarios of some 200cm or 80 inches of possible sea-level rise by the end of the century, with radically different vulnerability and climate impact outcomes as a result.[11]

Impacts have been estimated in either economic terms, for example, as a share of costs from, say, flood damage or losses/gains in productive output. Or they are expressed in human terms, such as populations under stress due to desertification, or mortality as a result of more severe weather or disease. The same methodology is applied to all countries, so the level of vulnerability ascertained is roughly comparable from one place to another.

If some steps have already been taken to adapt to changes -- such as disaster-reduction measures in Bangladesh that have greatly reduced fatalities during major storms -- a lower vulnerability will be registered. The longer in the past any such actions were taken and continuously maintained, the more likely they are to have an effect on the vulnerability factor of the country concerned.

Not taken into account is the level of domestic/international resources available to a country to deal with these challenges. And so the United States, for example, registers similar vulnerability levels to Gabon or Tonga, despite fundamentally different degrees of capacity available for confronting these vulnerabilities.

EFFECTS CAN ALSO BE POSITIVE

Climate change does not only have a negative impact. Agriculture, for instance, is an industry highly vulnerable to harmful effects of climate change. It is also an industry susceptible to the positive influences of that change, at least in the medium term, and depending on a country's location and other key variables. Many countries, for example, near the equator, who receive less rain and have rocketing heat stress, are seeing crop and livestock productivity decline. Whereas countries farther north or south, that are receiving more rainfall

MANY COUNTRIES HAVE ALREADY BEGUN TO FAMILIARIZE THEMSELVES WITH THEIR OWN VULNERABILITIES ON THE BASIS OF LONGER TIME SCALES, THEY MAY WELL BE SURPRISED WHEN VIEWING THAT VULNERABILITY ON A MUCH SHORTER TIME HORIZON

and experiencing longer growing seasons are likely already reaping benefits of improved productivity.

In all cases, the possible negative and positive effects are weighed together and given an impact level, either negative or positive. A vulnerability factor is then derived for each impact area based on the relative level of impacts ascertained for different countries. The factors themselves are created via a statistical normalization.

Higher factors of vulnerability are further away from the value where no harmful climate effect at all is perceptible. A factor of Acute + generally equates to three orders removed -- or mean average deviations -- from the baseline of no climate impacts.[12] A factor of Low means no perceptible vulnerability to the negative impacts of climate change. But many countries with a factor of Low vulnerability may well be reaping net benefits in certain areas. The degree of benefits is not recognized by the vulnerability factor, because from the moment impacts are neutral or positive they are no longer a vulnerability concern. Impact levels across the different indicators -- be they additional deaths or otherwise -- are given at the global and regional level and at national levels in various points, in particular in the country profiles also found in this report.

Countries with higher vulnerability factors do exhibit higher levels of impacts and typically require correspondingly greater attention in order to reduce those impacts. A country with a factor of Low will typically require no measures, since no negative effects are registered. A country with a factor of Moderate will typically require that certain measures be taken in order not to receive a negative impact. A factor of Acute may require many more times the scale of measures in order to prevent orders

THE UNITED STATES, FOR EXAMPLE, REGISTERS SIMILAR VULNERABILITY LEVELS TO GABON OR TONGA, DESPITE FUNDAMENTALLY DIFFERENT DEGREES OF CAPACITY AVAILABLE FOR CONFRONTING THESE VULNERABILITIES

of magnitude of impacts several times higher than for lower factors of vulnerability. Any country with a factor above Moderate is dealing with an unacceptable level of vulnerability, since cost-effective measures exist to reduce negative climate impacts and therefore minimize the vulnerability also.

Cost-effective measures are listed in the Adaptation Performance Review in this report and give an idea of the relationship between preventative investments and the losses indicated in the Monitor, which they aim to minimize. Measures aimed at reducing loss of life due to health impacts of climate change are particularly cost effective. Measures aimed at reducing impacts to human habitats and economic stresses are, on average, more costly to implement but still carry high benefits in many cases.

UNCERTAINTY AND RESPONSE

The accuracy of the Monitor does have its limitations. Estimates of impacts can be higher or lower, and the figures included here should be considered a robust set of possible outcomes around which planning and responses can be developed. Given clear indications of danger, responses cannot be delayed any longer because of an absence of complete scientific certainty.

In reality, these uncertainties mean, for example, that a country could easily have one full factor of vulnerability higher or lower than stated here. So a country with a factor of Severe could quite possibly have either a factor of Acute or High. That would be well within the margins of error involved in this work. While the Monitor bases itself to the extent possible on recent historical records of impact, all 2010 and 2030 values are estimates.

Within the uncertainty however, it is very unlikely that a country with a factor of Acute or Severe could in reality have a factor of Moderate or Low. Countries should, therefore, at a minimum be prepared for a level of impact corresponding to its assigned factor. But prudent planning would dictate a response commensurate to one factor higher than that assigned here, particularly if there is a probability of lives being at stake. Countries with the highest factor of Acute require special attention, since they most likely exceed by far any acceptable level of vulnerability and will necessitate correspondingly extreme measures in order to minimize harm done.

ANY COUNTRY WITH A FACTOR ABOVE MODERATE IS DEALING WITH AN UNACCEPTABLE LEVEL OF VULNERABILITY, SINCE COST-EFFECTIVE MEASURES EXIST TO REDUCE NEGATIVE CLIMATE IMPACTS

In the different impact areas, for the factors of High, Severe, and Acute we have also used two sub-factors “+” or “-”, so, for example, “Acute+” or “Acute-”. This indicates whether a country is in the first/bottom or second/top half within a given factor. “+” factors are more likely to fall into a higher category than “-” factors, and vice versa. Since the Monitor’s focus is to offer guidance on the countries that are facing serious impacts, Moderate and Low vulnerability factors have not been given sub-factors.

The Methodology section in the end matter of this report provides a fuller explanation of all aspects of the Monitor and its many indicators.

LIMITATIONS

Aside from basic uncertainties, limitations are evident in a number of other respects. For one, climate and nation state rarely match up. Desertification or sea-level rise may only be felt in one small part of a country. Or some highland areas could benefit from longer growing seasons or more rainfall, while other parts of a country are scorched or parched. These effects are, of course, averaged across the Monitor, which uses countries as its unit of analysis because of data availability (health statistics, for instance, are mainly national) and because governments are expected to lead much of the response to climate change. However, the nation-state unit of analysis should not detract from the Monitor’s insistence on people and communities as an organizing concept.

THE NATION-STATE UNIT OF ANALYSIS SHOULD NOT DETRACT FROM THE MONITOR’S INSISTENCE ON PEOPLE AND COMMUNITIES AS AN ORGANIZING CONCEPT

organizing concept that takes its cue from the 2009 Global Humanitarian Forum publication, The Anatomy of A Silent Crisis, which strongly articulated the underappreciated human dimensions of climate change and vulnerability to it.[13]

In many cases, such as for extreme weather, this report relies on estimates based on observational increases in storms or floods. But a five-percent increase in weather may be all the difference between a disaster and none at all -- if, for example, the capacity of a community to withstand the impact is overwhelmed by the seemingly small additional increase. In the areas of extreme weather, fisheries, and other fields not included here, such as infection rates for key climate-sensitive diseases, there is yet to be any sound scientific attribution quantifying a possible aggravating effect due to climate change. Despite the difficulties of establishing detailed climate role attributions, these are nevertheless vital to the development of any sound responses to possible impacts and are urgent research demands requiring much greater attention.

A number of decisions have been made to exclude indicators so that assessment of vulnerability is as consistent as possible from one country to another. Indications of mortality due to health problems or extreme weather are relied on, for example, but rates of infection, people in need of assistance ("affected"), people displaced, and people injured are not. Reporting of the excluded indicators varies widely around the world and might lead to underestimating the comparative vulnerability of some countries. But mortality only gives a proxy for the true extent of the health impact, where tens of thousands of people might be infected. Likewise, the number of deaths due to a storm or flood give no clear indication of how many people – sometimes millions – might be in need of assistance or temporary or permanent housing.

In the same way, since the Monitor gives scales of impacts averaged over the course of one year, it does not provide an idea of how a large problem might have been in a very short space of time. This is less of a problem when we look at generalized economic stresses, losses in human habitat, or certain health effects. The numbers could be quite misleading with respect to extreme weather, when many years worth of impacts could occur in less than 24 hours. Or impacts that the Monitor provides as averages per year may not even occur in a given country during one year or even several years. For this reason, a series of Peak Impacts are given within each of the main Monitor impact area sections. While there is no clear indication or inference that these events are attributable to climate change to any degree, they do provide an indication of how severe some climate-related phenomenon can become.

While the impact areas included in the Monitor were chosen for their ability to capture a wide picture of vulnerability. Many effects have not been touched on here, primarily because little research was available to draw upon in order to quantify a meaningful relationship with climate change. Impacts on sectors of the economy other than agriculture, for example, such as the tourism or transportation industries, have not been taken into account. Climate-related displacement or migration is only dealt with indirectly in relation to sea-level rise and desertification. Conflict and security issues are not touched on at all because of the very preliminary nature of that debate, despite the fact that almost all ongoing conflicts are occurring in countries highly vulnerable to climate change, and the fact that fragile states dominate the ranks of the most vulnerable.[14] A more detailed account of research gaps that affect the accuracy and breadth of this report and the Monitor is included in the end matter. It is primarily for this reason that we believe the Monitor most likely underestimates the scale of the impact of climate change on human society.

The chosen data can also be an issue. Venezuela, for example, registers 30,000 deaths in the main global disaster database for the 1999 Vargas flood tragedy. But a recent study estimates that the death toll could not have been more than 700. Since the Monitor assumes past scales of impact can provide one facet of an indication of future scales of impact, where climate change will play a small aggravating role, such a discrepancy would artificially inflate the climate vulnerability of a country.

Finally, the climate models used to support the Monitor have been chosen for close comparability, but not all follow precisely the same future emissions or climate scenario and the base years used by models also varies. Some of these issues are minimized by the fact that the Monitor only assesses vulnerability for 2010 and 2030. On longer time horizons, different emission and climate scenarios could have wildly dissimilar results.

MANY YEARS WORTH OF IMPACTS COULD OCCUR IN LESS THAN 24 HOURS

TOWARDS COMPREHENSIVE RESPONSES

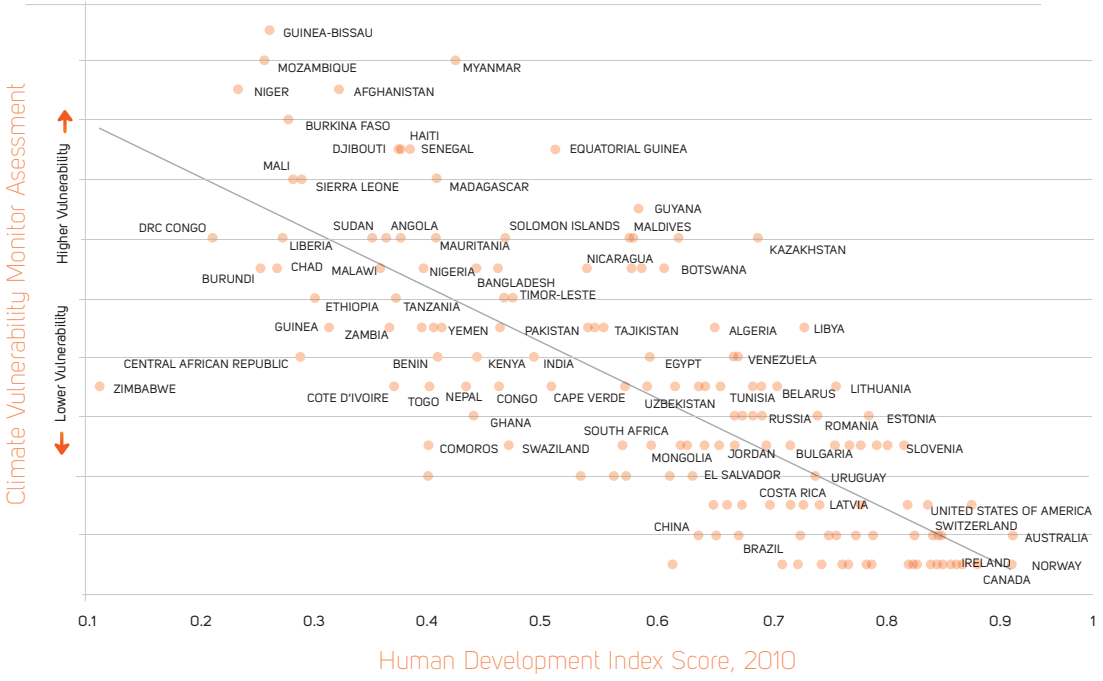
While this report's Adaptation Performance Review provides a good overview of some of the key actions that can be taken to reduce impacts identified in the Monitor, the non-exhaustive catalogue of actions covered in the Review are only one aspect of a much broader response that is necessary to tackle the impact of climate change.

Indeed, since many of the most vulnerable countries are also suffering from extreme poverty and weak state institutions, a good number of the actions assessed in the Review may be very difficult to implement if wider political, structural, and socio-economic concerns are not also addressed. So reducing vulnerabilities implies reinforcing socio-economic development, promoting gender equality, promoting strong political, legal, and institutional governance as well as effective public services, and, in particular, working to achieve the Millennium Development Goals -- the most internationally recognized objectives in the fight against poverty.

Chief among the known drivers of climate vulnerability are poverty, governance, and gender development, as outlined in the 2007/08 UNDP *Human Development Report*.[15] From this starting point, some preliminary analysis has been conducted comparing the Monitor's findings with three well-recognized indices of headline climate vulnerability drivers: the Human Development Index, the Gender Inequality Index, and, most recently, the Multi-Dimensional Poverty Index.[16]

CLIMATE VULNERABILITY AND HUMAN DEVELOPMENT

Correlation between the climate vulnerability monitor assessment and human development index score

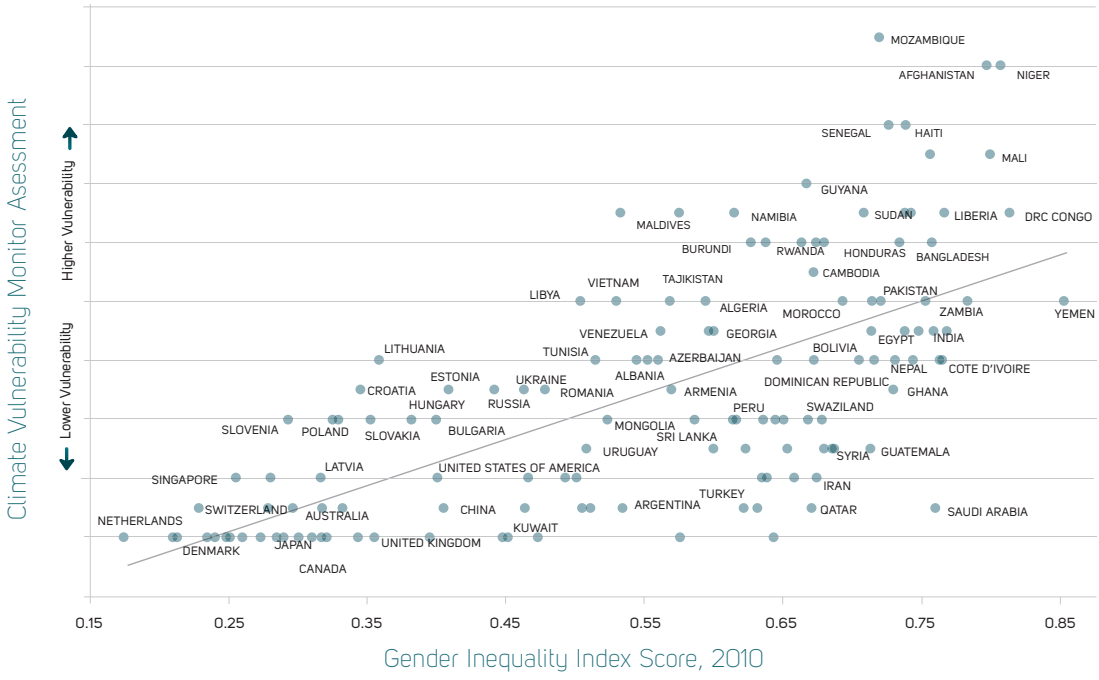


Each of these indices demonstrates a strong relationship with the Monitor. The most pronounced is the apparent link between the Human Development Index and the Monitor, whereby human development steadily decreases with every factor increase in climate vulnerability. Gender inequality and multi-dimensional poverty also increase together with rising climate vulnerability. So climate-vulnerable countries are more likely to have high levels of gender inequality

or poverty. Gender development is particularly important for human health impacts of climate change, which disproportionately affect children in developing countries, who are most likely cared for by their mothers or other female family members or friends.[17] However, women have a role to play across all aspects of the Monitor, given their recognized positive contributions to enhancing democratic governance, education, and disaster risk reduction work, as well as to economic prosperity and social cohesion.[18]

CLIMATE VULNERABILITY AND GENDER INEQUALITY

Correlation between the climate vulnerability monitor assessment and gender inequality index score



Outside of these strong correlations, there are a number of countries, for example, of comparative human development with significantly higher or lower climate vulnerability than the norm. This defies rigid adhesion to the idea that low human development equates in exactly equal measures to climate vulnerability. Higher climate vulnerability than that of countries with similar levels of human development in general implies greater exposure to changing weather or environmental conditions linked to climate change. For reasons of geography alone, not all poor or less-developed countries are exposed to the same degrees of climate stress.

This information can help identify how we can best apply socio-economic strategies to reduce systemic vulnerabilities. For example, Equatorial Guinea, the Maldives, Myanmar, and Vanuatu are all affected well beyond other countries with similar levels of socio-economic development. These countries require special attention if prosperity is to be upheld in the face of growing climate impacts that each is already feeling disproportionately compared with similarly developed countries.

FOR REASONS OF GEOGRAPHY ALONE, NOT ALL POOR OR LESS-DEVELOPED COUNTRIES ARE EXPOSED TO THE SAME DEGREES OF CLIMATE STRESS

ACUTE
Mean country 2010/2030: Burkina Faso/Nigeria

# COUNTRIES: 54			AVERAGE HUMAN DEVELOPMENT	0.37 - Low
IMPACT AREA	**2010**	**2030**	**AVERAGE COUNTRY IMPACT (ABSOLUTE/2030)**	
OVERALL	15	54	MORTALITY – CLIMATE SENSITIVE DISEASES	17,000 deaths/year
HEALTH IMPACT	22	42	MORTALITY – EXTREME WEATHER	200 deaths/year
WEATHER DISASTERS	12	20	POPULATIONS AT RISK – DESERTIFICATION	220,000 people
HABITAT LOSS	22	48	SEA-LEVEL RISE COSTS (USD PPP)	900 million dollars/year
ECONOMIC STRESS	28	68	OTHER SECTOR/ASSET COSTS/ LOSSES (USD PPP)	1.2 billion dollars/year

Acute countries comprise the most vulnerable category. Impacts registered are far beyond the global norm. Acute countries are experiencing large proportions of the overall global impacts due to climate change. Any country with a factor of Acute in just one area could be facing damages of great significance. However, many Acute countries are already facing serious challenges of human development, the rule of law and social and gender inequalities. Handfuls of countries are assessed as Acute. However, unless actions are taken to counteract the negative effects of climate change, by 2030 this category will explode some two-fold.

SEVERE
Mean country 2010/2030: Bhutan/Côte D'Ivoire

# COUNTRIES: 28			AVERAGE HUMAN DEVELOPMENT	0.47 - Low
IMPACT AREA	**2010**	**2030**	**AVERAGE COUNTRY IMPACT (ABSOLUTE/2030)**	
OVERALL	31	28	MORTALITY – CLIMATE SENSITIVE DISEASES	4,000 deaths/year
HEALTH IMPACT	25	20	MORTALITY – EXTREME WEATHER	80 deaths/year
WEATHER DISASTERS	8	14	POPULATIONS AT RISK – DESERTIFICATION	25,000 people
HABITAT LOSS	11	19	SEA-LEVEL RISE COSTS (USD PPP)	450 million dollars/year
ECONOMIC STRESS	49	38	OTHER SECTOR/ASSET COSTS/ LOSSES (USD PPP)	650 million dollars/year

Severe countries are the second most vulnerable category. Impacts registered are well above the global norm. Severe countries contribute significantly to overall global impacts due to climate change, especially in 2010. Given the limitations of the methodology of the Monitor, any country with a factor of Severe could in reality have a profile of Acute. Severe countries are facing challenges that would place heavy additional stress in any given impact area. The majority of Severe countries will become Acute by 2030 unless action is taken to counteract the growing impact on these countries.

HIGH
Mean country 2010/2030: Cameroon/Macedonia

# COUNTRIES: 50			AVERAGE HUMAN DEVELOPMENT	0.58 - Medium
IMPACT AREA	**2010**	**2030**	**AVERAGE COUNTRY IMPACT (ABSOLUTE/2030)**	
OVERALL	51	50	MORTALITY – CLIMATE SENSITIVE DISEASES	1,000 deaths/year
HEALTH IMPACT	36	46	MORTALITY – EXTREME WEATHER	40 deaths/year
WEATHER DISASTERS	37	36	POPULATIONS AT RISK – DESERTIFICATION	8,000 people
HABITAT LOSS	47	25	SEA-LEVEL RISE COSTS (USD PPP)	400 million dollars/year
ECONOMIC STRESS	64	59	OTHER SECTOR/ASSET COSTS/ LOSSES (USD PPP)	1.7 billion dollars/year

High countries are the third most vulnerable category. Impacts registered are above the global norm by a degree of some significance. High countries are especially remarkable for their strong contribution to overall economic losses, due to the large number of emerging and highly developed countries in the category, especially as expected for 2030. Given the limitations of the methodology of the Monitor, any country with a factor of High could in reality have a profile of Severe or Moderate. High remains a stable category between 2010 and 2030, since many High countries will graduate to a factor of Severe by 2030, and many Moderate countries will likewise have a vulnerability profile equating to a factor of High by that same time.

MODERATE

Mean country 2010/2030: Sri Lanka/Australia

# COUNTRIES: 33			AVERAGE HUMAN DEVELOPMENT	0.72 - High
IMPACT AREA	**2010**	**2030**	**AVERAGE COUNTRY IMPACT (ABSOLUTE/2030)**	
OVERALL	61	33	MORTALITY – CLIMATE SENSITIVE DISEASES	300 deaths/year
HEALTH IMPACT	92	33	MORTALITY – EXTREME WEATHER	25 deaths/year
WEATHER DISASTERS	127	114	POPULATIONS AT RISK – DESERTIFICATION	Nil
HABITAT LOSS	82	69	SEA-LEVEL RISE COSTS (USD PPP)	275 million dollars/year
ECONOMIC STRESS	39	13	OTHER SECTOR/ASSET COSTS/ LOSSES (USD PPP)	450 million dollars/year

Moderate countries are the first real vulnerability category, since Low countries are expected to experience little negative impacts or even positive benefits as a result of short-term climate change. Impacts registered are only more or less at the global norm, hence the large numbers of countries in this category. Due to the limitations of the Monitor's methodology Moderate countries could easily also be either High or Low. In general, Moderate countries are not heavily impacted in more than one area as a result of climate change. Although many Moderate countries will progress in their vulnerability to High by 2030.

LOW

Mean country 2010/2030: France/Japan

# COUNTRIES: 19			AVERAGE HUMAN DEVELOPMENT	0.84 - Very High
IMPACT AREA	**2010**	**2030**	**AVERAGE COUNTRY IMPACT (ABSOLUTE/2030)**	
OVERALL	26	19	MORTALITY – CLIMATE SENSITIVE DISEASES	Nil
HEALTH IMPACT	9	50	MORTALITY – EXTREME WEATHER	Nil
WEATHER DISASTERS	Nil	Nil	POPULATIONS AT RISK – DESERTIFICATION	Nil
HABITAT LOSS	22	23	SEA-LEVEL RISE COSTS (USD PPP)	750 million dollars/year
ECONOMIC STRESS	4	6	OTHER SECTOR/ASSET COSTS/ LOSSES (USD PPP)	(5 billion)* dollars/year

Low countries register no vulnerability due to climate change or even positive benefits in some areas. The only area where countries with a factor of Low vulnerability register any impacts as a result of climate change is in the area of sea-level rise, where impacts will be felt, at least to a small degree, anywhere there is a coastline. Due to the limitations of the Monitor's methodology Low countries could easily also be Moderate, although it is extremely unlikely that countries with a factor of Low would have anything more than Moderate of High vulnerability to climate change in reality. There is a surge of countries with a factor of Low vulnerability in the impact area or health through to 2030, due to the increasing health benefits due to warmer weather, and shorter, warmer winters in higher latitude countries by this time. Otherwise the category is generally static, with most of the category Low countries retaining their vulnerability status over the next 20 years, due mainly to extremely high average levels of human development.

*Parentheses/brackets indicate a net gain in economic terms for Low factor countries in 2030

PEAK IMPACT

Peak Impact gives an idea of how large some disasters linked to climate change can be. The numbers provided by the Climate Vulnerability Monitor are often annualized averages of possible impacts based on historical or actual statistics. However, many countries are only hit once in a decade, with potentially all the impact falling in just one day or one month. It should not be inferred that climate change is fully responsible for any of the events referred to in the Peak Impact series in this report. Although the additional stress of climate change may in particular be responsible for triggering large disasters that occur especially when the usual levels of impact familiar to populations are exceeded. Peak Impacts provide an example of the types of extremes already experienced across different impact areas around the world since the year 1997.

HEALTH IMPACT

Disease not disasters account for the vast majority of human deaths due to climate change. Higher temperatures and stress on water and food supplies do have serious impacts on human health, but changes in climate also enable some of the world's biggest killers – malnutrition, diarrhea, and malaria – to take a heavy toll. Mothers and children are worst hit by these illnesses.

2010
CLIMATE EFFECT TODAY
350,000 DEATHS PER YEAR

2030
CLIMATE EFFECT TOMORROW
840,000 DEATHS PER YEAR

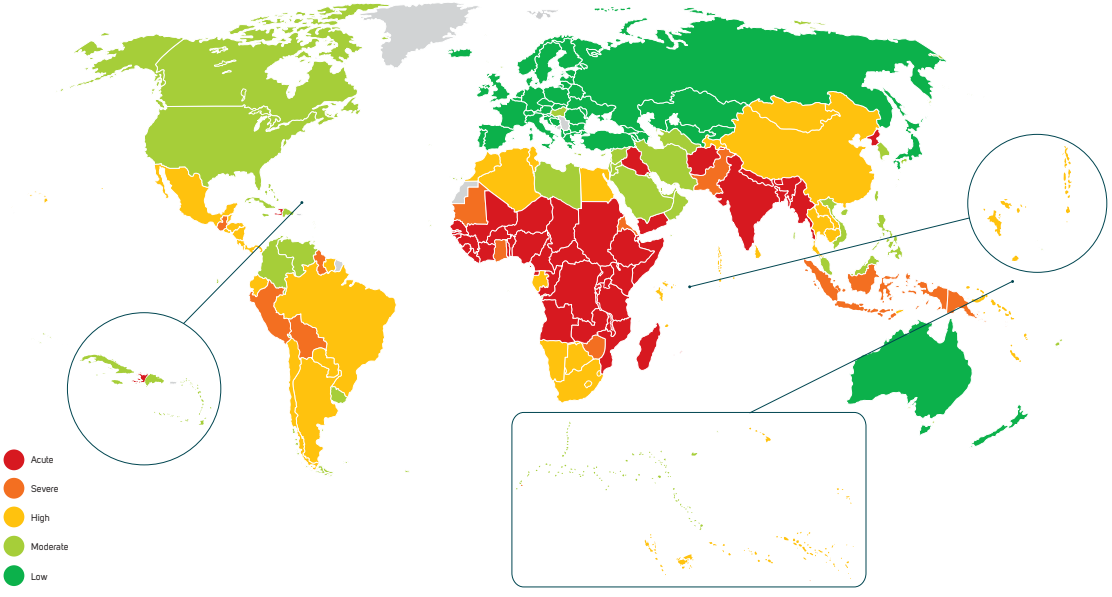
FINDINGS

An estimated 350,000 people die each year due to major diseases and health disorders related to climate change. Unless measures are taken, by 2030 climate change will increase its toll to more than 800,000 deaths per year.

Vulnerabilities to diseases related to climate change are very unevenly distributed around the world but fall most severely on the shoulders of the poor and particularly affect the children of those vulnerable communities.

GLOBAL VULNERABILITY TO CLIMATE HEALTH IMPACT

Countries by overal climate vulnerability for health

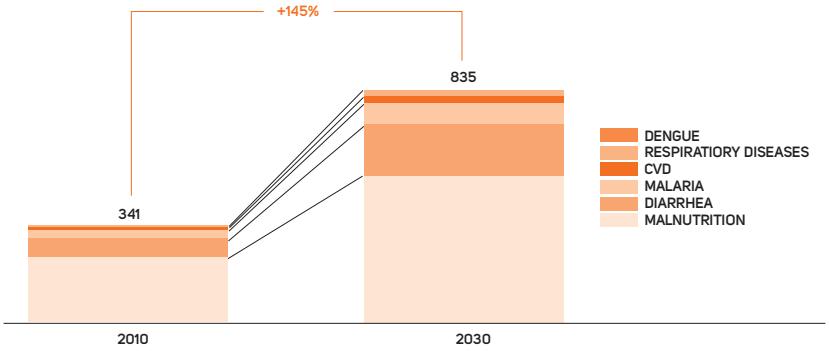


By far the majority of climate change-related deaths are due to malnutrition, diarrhea and malaria. These are already three of the greatest causes of avoidable deaths around the world, particularly in the poorest countries.[19] Climate change contributes to around 230,000 of the more than 3 million deaths attributable to malnutrition and acute respiratory infections each year. That number will increase to around half a million by 2030. The next biggest killer associated with climate change is diarrhea, with some 70,000 out of 2 million deaths today, growing to around 190,000 deaths by 2030. Out of the 1 million deaths malaria now causes, some 25,000 are estimated to be linked to climate change, growing to 75,000 by 2030.

GLOBAL CLIMATE HEALTH IMPACT BURDEN

The change in the scale of global climate-related health mortality from 2010 to 2030

Additional Deaths (1000s) average per year



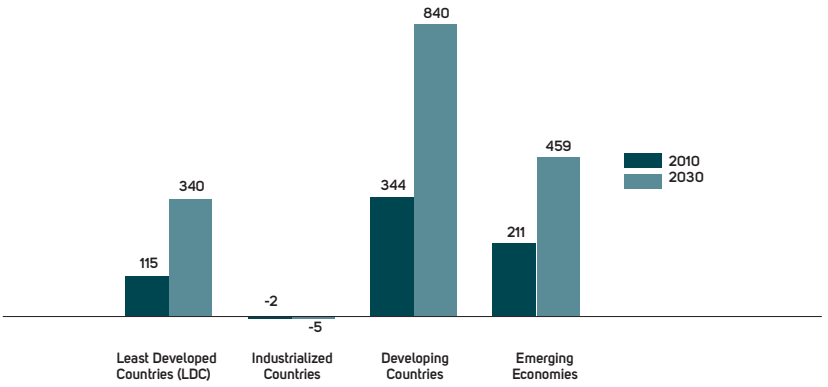
This progression is based on projections of increasing temperatures and other climate-related stresses over the next 20 years. It also incorporates population growth projections.

Least-developed countries will bear more than a third of this health burden, projections show. And developing countries are projected to bear practically the entire incremental disease burden due to climate.

THE SPREAD OF IMPACT: MORTALITY

The distribution of climate-related health mortality by socio-economic group in 2010 and 2030

Additional Deaths (1000s) average per year



These deaths are preventable, since an array of cost-effective measures exists, and in most countries with even moderately high income levels, there is no underlying burden of the main diseases that climate change reacts with.[20] Poverty is therefore the main cause of the underlying vulnerability to these health problems as well as the greatest impediment to countering that vulnerability.

IMPACT DYNAMICS

CLIMATE AND HEALTH

The influence of climate on human health is widely researched and accepted.[21]

The impacts range from asthma through to influenza, vector-borne and waterborne diseases, heat-related deaths, and even mental health problems.[22]

This report's analysis builds on the detailed work in particular of the World Health Organization, including the development of climate change risk factors for headline diseases that have been subject to expert review and detailed discussions in academic publications, such as British medical journal *The Lancet*.[23]

The focus here is to outline the main causes of climate change-related health problems. In addition to malnutrition, diarrhea and malaria, those causes include respiratory and cardiovascular illnesses that react to high temperatures, and dengue fever, a vector-borne disease spreading in ways similar to malaria.[24]

Only mortality is used as an indicator for the climate-health assessment, and not, for example, morbidity or infection rates, because deaths offer us the most accurate means of measuring and projecting climate change impacts. The research examines linkages between climate vectors (such as temperature) and specific diseases, using techniques common to the health field to model estimated impacts and to guide interventions.[25]

PEAK IMPACT HEALTH ▲

2003	Europe	Heat Wave	70,000 additional deaths - mainly among the elderly –1 of the 10 deadliest natural disasters in Europe in last 100 years[26]
2004	Indonesia	Dengue Fever	Over 58,000 infected, 658 deaths[27]
2006	India (northeast)	Malaria	25,000 infected, 50 died[28]
2008-2009	Zimbabwe	Cholera	98,741 infected and 4,293 deaths. Deadliest African cholera outbreak in the last 15 years[29]
2009	Bolivia	Dengue Fever	31,000 infected. A national emergency was declared[30]
2010	Haiti	Cholera	Death toll estimated at 442 as of November 2010 - first verified outbreak in the country[31]

FLASH FLOODS BRING SEWERAGE AND OTHER WASTE INTO CLOSER CONTACT WITH PEOPLE AND CONTAMINATE FRESH WATER SUPPLIES

EXTREME HEAT

Heat and its relationship to disease stands out quite clearly. The extreme 2003 European heat wave resulted in some 70,000 more deaths than usual, mainly among elderly individuals who had already been suffering cardiovascular and respiratory illnesses.[32] Heat waves, of course, are expected to be more common in many areas as a result of climate change.[33] But hot, water-stressed countries – like many African nations – are in general more vulnerable than cooler, wetter regions.

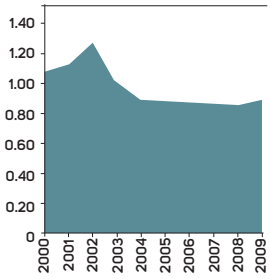
These more vulnerable regions experience more than cardiovascular and respiratory diseases because of the heat. The higher temperatures and more humid climates caused by climate change favour bacteria growth and growth in the populations of insects and vectors that spread diseases.[34]

Insects such as mosquitoes breed faster in such conditions and can thereby spread illnesses more widely. Temperature may also accelerate the rate at which vectors (such as mosquitoes) replicate diseases within their bodies, so they become infectious faster and spread diseases faster.[35] In the most extreme conditions of heat and water stress, however, mosquitoes can no longer thrive, and large-scale floods can wash away mosquito larvae.

Malaria and dengue fever are expected to spread more widely.[36] The burden of vector-borne diseases will likely also spread to higher altitudes as mountainous zones warm up.[37] When diseases spread to communities unaccustomed to dealing with them, the health impact can be particularly severe, as local health systems and populations are ill equipped to respond.[38] The number of days or months of exposure are also expected to increase.[39] Yellow fever, not covered here, could react similarly to dengue and malaria.[40]

OVERALL DEATHS FROM MALARIA

Millions



Source: WHO

Water scarcity and water quality are important drivers of health. Less rainfall

VECTOR-BORNE DISEASES WILL LIKELY SPREAD TO HIGHER ALTITUDES AS MOUNTAINOUS ZONES WARM UP

causes problems in areas where drought and evaporation levels are on the rise, but more rainfall is problematic in areas where heavy rains or flash floods bring sewerage and other waste into closer contact with people and contaminate fresh water supplies.

Infections borne by food and water, such as salmonella and typhoid are expected to increase, including in Europe and North America.[41] Warming waters in coastal areas also favour the development of cholera bacteria.[42] The diarrhea mortality indicator in this report measures some of the impact of these infections.

HUNGER AND MALNUTRITION

Malnutrition, however, is the biggest challenge of all, since it is projected to account for the majority of deaths linked to climate change. Agriculture is highly sensitive to climate change, as discussed in detail in the Economic Stress section of this report. More variable and extreme weather, and changing rainfall patterns can reduce the local availability of food, heightening malnutrition rates especially among the poorest rural populations.[43]

Agricultural yields from key cereals are expected to suffer widespread decline by 2050, especially in poor countries, where marginal growing conditions mean fertility benefits from higher CO_2 on which plants feed, for instance, are unlikely to be realizable in practice.[45] Livestock will also suffer declines in many instances, since the grass or feed they are raised with is under stress too.[46] Subsistence farmers and other low-income groups with limited access to food supplies are likely already suffering from an added burden of malnutrition in areas where rainfall has decreased and water scarcity and high heat are driving down local food production.

FISHERIES

Impacts on fisheries are also contributing to malnutrition. Shifts in global fish stocks away from the tropics due to higher temperatures, coral bleaching, and increasing ocean acidity have already been established. These impacts are increasing the rate of malnutrition in affected communities that are heavily reliant on fish as their main source of food.[47]

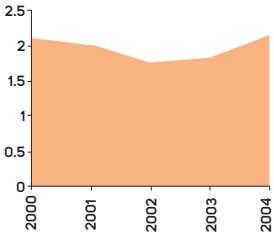
While some regions will benefit from short- to medium-term improvements in agriculture, across fisheries, crops, and livestock, the global availability of food will be under increased stress due not only to climate factors, but also in large part to population growth and increasing demand.[48] And the local negative impacts of climate change are generally worst in regions already badly affected by malnutrition.[49]

The Adaptation Performance Review in this report demonstrates the wide array of extremely cost-effective measures that are readily available to any community with the resources and capacity to implement them. Millions of preventable deaths occur every year due to lack of access to these solutions.

The main climate-sensitive diseases – malnutrition, malaria and others – have been decreasing globally over the last decade. But climate change is compounding these key health problems just as significant resources are being invested into their eradication.

DEATHS FROM DIARRHEAL INFECTIONS

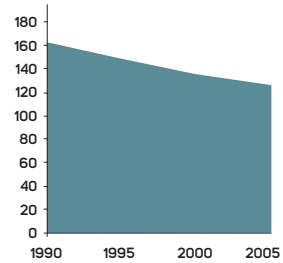
Millions



Source: WHO

UNDERWEIGHT PREVALENCE

Millions preschool children



Source: International Journal of Epidemiology 2004;33:1260–1270

There is some evidence of a decreasing prevalance in overall global malnutrition rates in recent times, mainly due to sustained economic development and improved programmes combating this deadly health concern.[44] Climate change risks halting or even reversing that positive trend through increased drought, water stress and other climate shocks.

LINKS FROM CLIMATE CHANGE TO IMPACT INDICATORS

CLIMATE CHANGE EFFECTS	PHYSICAL CHANGES	VULNERABILITIES	IMPACT INDICATORS
• Changes in temperature • Changes in local rainfall	• Droughts • Increasing water pressure • Reduced crop yields	• Food security: Hunger / nutritional status • Lower respiratory infections	Impact of malnutrition • Described as deaths related to malnutrition and lower respiratory infection due to climate change
• Changes in local rainfall and river run-off patterns • [Melting glaciers]	• Increasing water pressure • Inland floods • Coastal floods	• Diarrhea • Access to clean drinking water • Access to basic sanitation • Water-borne diseases	Impact of diarrhea • Described as deaths related to diarrhea due to climate change
• Changes in temperature • Changes in local rainfall	• Changes in environmental conditions for disease vectors • Floods / standing water	• Expansion of disease-endemic zones for vector-borne diseases • Increased transmission of malaria and other vector-borne diseases	Impact of vector-borne diseases • Described as deaths related to malaria and dengue due to climate change
• Extreme thermal exposures	• More frequent extreme temperature events (heat and cold)	• Stroke • Asthma	Impact of extreme heat events • Described as deaths related to cardio-vascular diseases and respiratory diseases due to climate change

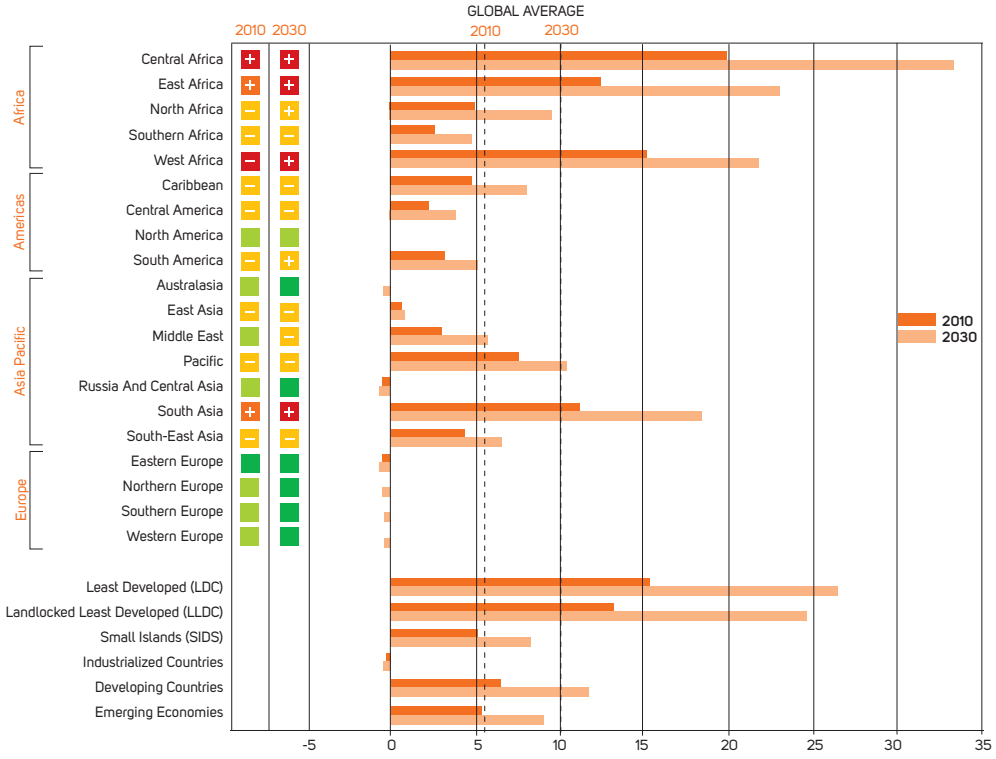
WHO SUFFERS?

The world's poorest countries are the ones most vulnerable to the health impacts of climate change. They have the largest existing burdens of climate-sensitive diseases and the least effective public health systems.[50] A very large share of the burden of malaria, for instance, is experienced in Africa. Low-income countries are also experiencing some of the most severe environmental changes that negatively impact health, such as extreme heat and water stress. The worst-affected regions are in Sub-Saharan Africa and Asia. The Pacific islands states are also projected to face significant additional disease burdens due to climate change.

IMPACTS AROUND THE WORLD

The regional and socio-economic distribution of climate-related mortality relative to population in 2010 and 2030

Deaths per 100,000, average per year



Due to the warmer, milder winters that climate change will bring to cooler countries, we will see low vulnerability to climate-related health problems expand across wealthy countries. An additional 45 countries will achieve low vulnerability by 2030 mainly for these reasons.

But any benefits these areas see are dwarfed by the costs to human life and well-being that low-income communities experience. Indeed, on current trends, the global human health impact is set to increase by more than 100% by 2030 if we do not take measures to counteract the growing negative effects of climate change.

Although Africa experiences the heaviest impacts of climate change on human health, Afghanistan ranks as the single most vulnerable country to this type of climate impact. The landlocked, mountainous, relatively high-altitude country is one of the world's poorest, ranking in the bottom 15 countries of the UN Human Development Index.[51] Afghanistan has also been in a continual state of conflict since the late 1970s. Conflict and poverty disable the country's capacity to prevent and control this high disease burden. Without stronger action to contain this increasing burden, climate change could be responsible for claiming tens of thousands deaths in Afghanistan every year by 2030. Other highly vulnerable countries include

GLOBAL HUMAN HEALTH IMPACT IS SET TO INCREASE BY MORE THAN 100% BY 2030

Somalia and a number of other post-conflict or conflict-prone countries, such as Sierra Leone, Angola, and the Democratic Republic of Congo.

LEAST AFFECTED

There are many countries with very low vulnerability to the health impacts of climate change. Since measures to prevent death are so basic that most fatalities are due to poverty, wealthy countries see very few instances of the main climate-related killers, such as malnutrition or malaria.

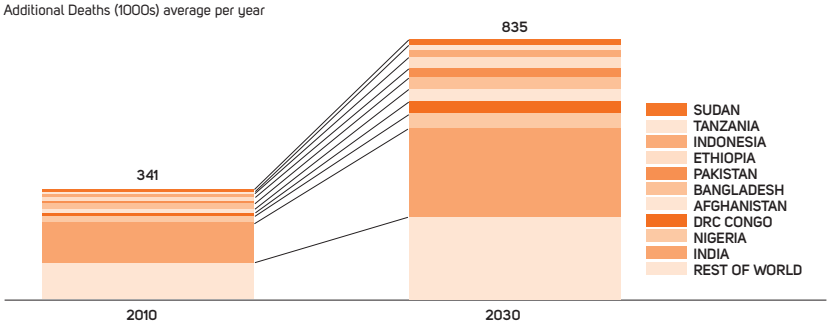
There are also a few countries that reap a positive benefit from climate change on their public health. This is because the higher temperatures may reduce the prevalence of stroke, asthma, and other diseases.[52]

In absolute terms, India is the country that will face the highest number of excess Deaths due to the health impacts of climate change. It alone will carry more than a third of the total global health burden.

HOTSPOTS: MORTALITY

Countries with the largest total climate-related health impact by number of deaths

Additional Deaths (1000s) average per year



WORST HIT AND LEAST HIT (2030)

The top 10 countries worst and least affected countries by the health impacts of climate change in 2030 relative to their size

WORST	LEAST
AFGHNISTAN	UKRAINE
SOMALIA	BULGARIA
NIGER	BELARUS
SIERRA LEONE	RUSSIA
ANGOLA	LATVIA
DRC CONGO	ARMENIA
BURUNDI	MOLDOVA
RWANDA	ROMANIA
MALI	ESTONIA
MALAWI	LITHUANIA

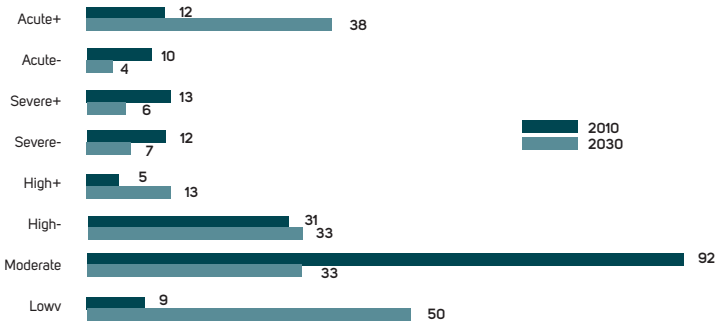
THE IMPACT TOMORROW: 2030

The Monitor projects the health impacts of climate change to polarize over the next 20 years. The 50 worst-affected countries are projected to experience accelerating health impacts. At the same time, the 50 least-affected countries are projected to experience very limited additional disease burdens, or even small benefits.

VULNERABILITY SHIFT

The change in the number of countries by each Vulnerability Factor between 2010 and 2030

Number of Countries by Vulnerability Factor



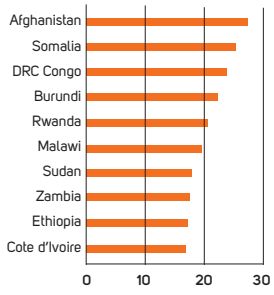
Almost every Sub-Saharan African region will become acutely vulnerable to climate change by 2030. This will also be the case for South Asia.

The countries whose vulnerability in this area is set to increase most rapidly are Afghanistan, Somalia and DRC Congo. Nine of the ten countries projected to face the fastest surge in disease burden due to climate change are in Africa.

HIGH SURGE VULNERABILITY

Countries with the fastest growing climate-related health impact between 2010 and 2030

Percentage increase in impact



SPOTLIGHT: DIARRHEAL INFECTIONS

The condition of excessive bowel movements, diarrhea, is another one of the biggest killers in developing countries today, responsible for around 2 million deaths per year. As with malnutrition, it almost never causes fatalities in wealthy countries. Diarrhea is also much less prevalent in developed countries where food and water contamination and spoiling are less common.[53] Most deaths brought on by diarrheal infections like cholera are the result of acute dehydration. Such deaths can be avoided with the simplest of treatments – a salt-water and sugar or rice-based drink called oral rehydration solution/therapy.[54]

Higher temperatures foster the growth of viruses, bacteria and parasites, which are passed on to people mainly via food and water. Where refrigeration is limited, higher temperatures also increases the rate at which food spoils, forcing more people to eat food unfit for consumption. Increased flooding also threatens fresh water supplies. All of these problems can lead to diarrhea and death in the absence of basic treatment.[55]

Climate change is therefore estimated by the WHO to cause roughly 3.5% of the burden of diarrhea in many countries.[56] The 70,000 annual deaths this represents today are expected to increase to around 180,000 by 2030 unless proper measures are taken.

THE ASSESSMENT

The Monitor assesses health impacts due to climate change by applying a sub-regional climate change risk factor developed by WHO to national climate-sensitive mortality statistics from 2004. WHO risk factors have been calculated for a range of different health concerns, such as smoking as a risk factor for lung cancer. Risk factors assume, for example, that climate change has a 3% role in a given burden of fatalities from a specific disease, such as malaria.[57] Regions such as Sub-Saharan Africa generally have higher risk factors compared to, say, North America, due to climate and other variables. But it is overwhelmingly the underlying burden of climate-sensitive diseases that plays the greatest determining role in whether a country is deemed to have a higher or lower factor of vulnerability to the health impacts of climate change. So countries where climate-sensitive diseases are more widespread have correspondingly higher factors of vulnerability. Mortality is assessed relative to total population, so impacts are assessed by their relative importance within a particular country.

There are nevertheless some surprising results from within Sub-Saharan Africa, which has the worst general burden of climate-sensitive diseases: Namibia (Moderate/Moderate), South Africa (Moderate/Moderate) and Zimbabwe (Moderate/High+) all have relatively low vulnerability, especially in 2010. Each of these countries has a high rate of HIV/AIDS, which can assist the spread of vector-borne illnesses such as malaria.[58] But South Africa, for example, has almost no diarrhea, malaria, or dengue burden, and has malnutrition rates similar to many fast-growing Asian countries, such as Sri Lanka. Namibia also has very low malnutrition, diarrhea, and dengue rates, but has a higher burden of malaria.[59] While Zimbabwe registers relatively high on diarrhea and malnutrition death rates, it has no dengue and little malaria, and so is much less vulnerable than the norm for the region.[60]

Argentina (High-/High+) -- onetime breadbasket of the world -- receives a surprisingly high factor of vulnerability for health compared to its peers in South America. Driving the vulnerability is a high of number of deaths due to malnutrition. From 1999 to 2002 Argentina experienced a serious financial crisis with the economy contracting each year resulting in many instances of malnutrition especially among children in remote rural locations.[61] The Monitor bases itself on the most recent globally relevant health data available from the WHO, which was sourced for 2004, at the tail-end of this crisis. Argentina is generally expected to have improved its general situation since this time, minimizing a key vulnerability flare to climate change.[62]

A young boy eats locally grown rice in Philippines, May 2008. Source: VJ Villafranca/IRIN.

WEATHER DISASTERS

More extreme weather is observed today than was recorded 30 years ago. Wind, rains, wildfires, and flooding have claimed lives throughout human existence. Climate change is intensifying these phenomena, worsening floods, storms, and wildfires that kill people and destroy property and livelihoods. The most devastating impacts of extreme weather, in particular tropical cyclones, are concentrated in poor tropical and sub-tropical zones of the world. Extreme weather becomes a disaster when communities are unprepared or caught off guard. But most disasters can be relatively easily prevented when people have access to effective early warning systems and basic protection.

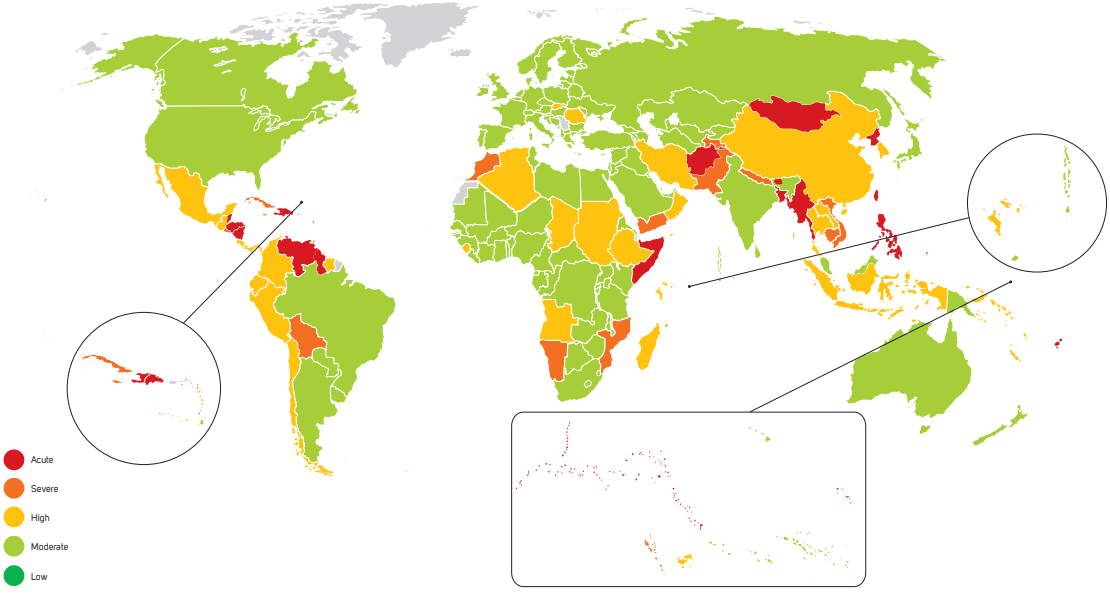
2010
CLIMATE EFFECT TODAY
3,500 DEATHS PER YEAR
4.5 BILLION DOLLAR IMPACT PER YEAR

2030
CLIMATE EFFECT TOMORROW
8,000 DEATHS PER YEAR
20 BILLION DOLLAR IMPACT PER YEAR

FINDINGS

GLOBAL VULNERABILITY TO CLIMATE WEATHER DISASTERS

Countries by overal climate vulnerability for weather



Climate change means more heat, warmer oceans, more evaporation, more energy, and either more or less rainfall. It also means more glacial and ice melt, often occurring more abruptly. Weather is becoming more unpredictable, with winds, storms, and rains changing patterns or tracks and intensities.[63] The tropical cyclone belts of Asia, the Caribbean, and the Pacific feel the worst impacts of floods, storms, and wildfires.

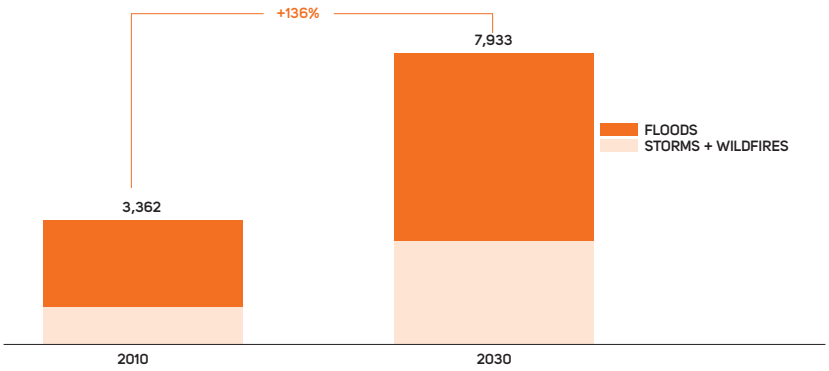
Floods, storms, and wildfires have claimed an average of 27,000 lives every year over the past 20 years.[64] Climate change is already estimated to contribute over 3,000 deaths to that toll each year. By 2030, climate change is projected to be responsible for over 7,000 such deaths if measures are not taken to reduce risks. The deadliest of these impacts today are floods. They are already estimated to claim 2,400 climate-driven deaths each year. And that figure will rise to more than 5,000 by 2030. Simultaneously, damage costs from weather disasters are projected to reach close to USD 5 billion each year already and to grow to USD 20 billion by 2030.

THE LARGEST ABSOLUTE LOSSES IN ECONOMIC TERMS ARE SEEN IN SOME OF THE WORLD'S WEALTHIEST COUNTRIES, INCLUDING THE UNITED STATES AND JAPAN

GLOBAL CLIMATE WEATHER DISASTERS IMPACT BURDEN: MORTALITY

The change in the scale of global climate-related weather disaster mortality from 2010 to 2030

Additional Deaths average per year



People living in poor communities in developing countries are the most vulnerable to extreme weather. Yet some of the largest absolute losses in economic terms are seen in some of the world's wealthiest countries, including the United States and Japan.

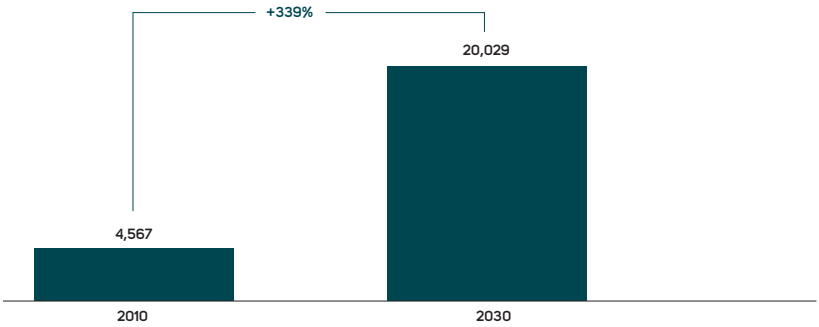
IMPACT DYNAMICS

Warmer atmospheric and ocean temperatures are being observed.[65] At the same time, observations of weather, especially via satellite, reveal an increase in flood events and suggest that tropical cyclones are increasing in intensity.[66]

GLOBAL CLIMATE WEATHER DISASTERS IMPACT BURDEN: DAMAGE COSTS

The change in the scale of global climate-related weather disaster damage costs from 2010 to 2030

Additional damage cost (million USD PPP) average per year



PEAK IMPACT WEATHER ▲

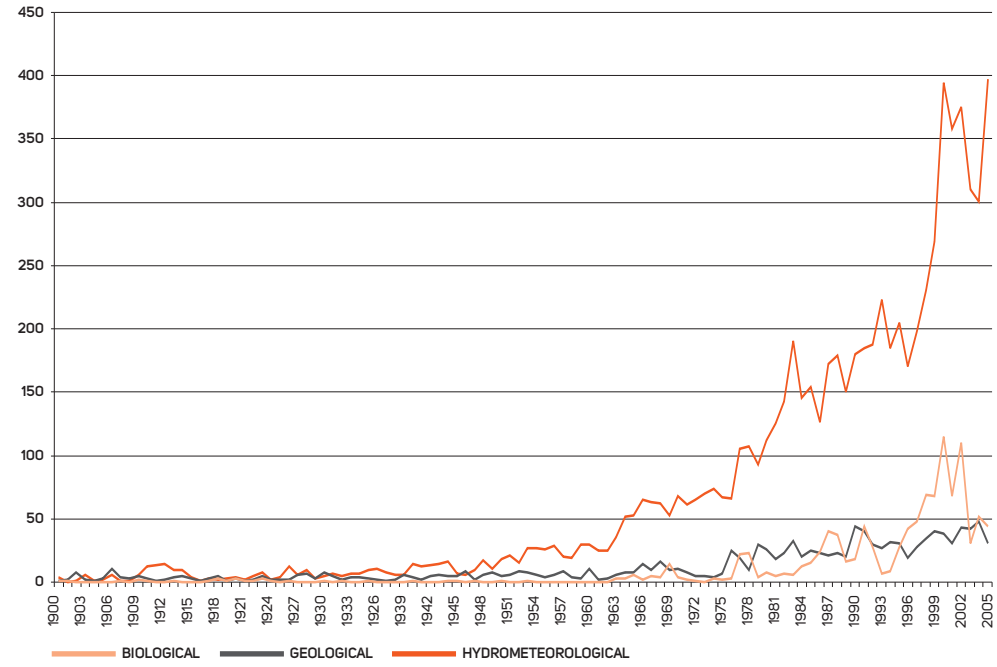
1998	Central America	Hurricane Mitch	18,811 deaths, more than 3 million affected-over $6 billion in damages[67]
2005	United States	Hurricane Katrina	1,833 deaths, 500,000 affected- $125 billion in damages[68]
2007	Bangladesh	Cyclone Sidr	4,234 deaths, 6 million left homeless - $2.3 billion in damages estimated[69]
2007	China	Flooding	Over 105 million affected and 535 killed - $4.4 billion in damages[70]
2007	Greece	Wildfires	5,392 affected- $1.7 billion in damages[71]
2007	USA (California)	Wildfires	292,098 ha burned, 24 killed, 120,000 displaced and $2 billion in damages[72]
2008	Myanmar	Cyclone Nargis	138,366 deaths - losses of $10 billion estimated[73]
2009	India	Flooding	992 killed, 1.9 million affected, and $220 million in damages[74]
2010	Pakistan	Flooding	Over 20 million affected, 2,000 killed -$9.5 billion in damages[75]
2010	Russia	Wildfires (from record temperatures and drought)	Cost $15 billion in damages - twice the average number of deaths due to heat wave and smog from fires[76]

RAINFALL AND CYCLONES

Rainfall is becoming heavier in North and South America, Northern Europe, and Central Asia.[77] This kind of heavy rainfall can overwhelm rivers and trigger rapid flooding.[78] At the same time, higher temperatures lead to lower rainfall and increased heat in other parts of the world, heightening the risk of droughts and wildfires.[79] A community's level of exposure to a weather disaster is related to that community's approach to managing its own habitats. For example, many fires are caused by human activity, often in the pursuit of livelihoods (farming and otherwise) and according to age-old practices.[80]

RECENT TRENDS IN ENVIRONMENTAL DISASTERS

Number of natural disasters registered in EMDAT 1900-2005



Source: IDSR/CRED (2010)

Cyclones have often been considered a hallmark characteristic of climate change. It is easy to understand that logic – warming seas and air cause more water to evaporate, sending more moisture and energy into the air, which then fuels strong rains and winds. The idea that cyclone activity is increasing as a result of climate change is actually one of the most contested areas of climate science.[81] Still, there is evidence to support the assertion. In 2007, the world's leading scientific body in this field, the IPCC, concluded that climate change was causing an increase in tropical cyclone activity in the North Atlantic, although it cited only limited evidence for other regions.[82] And at the same time, worldwide data collected by reinsurance company Munich Re showed a 30% rise in the number of flood and storm insurance loss events over the last 30 years.[83]

FLOODS

Increased flooding is mainly attributed to localized rainfall, often in the context of storms. But flooding also results from accelerated glacial- and ice-melt from alpine or Arctic-fed rivers.[84] Storms and floods can cause significant casualties and destruction to affected communities. Drownings, physical injuries, and disease are all part of the human toll of such events. Complex emergencies can emerge within days of a major weather disaster, crippling communities that are not equipped to handle them.[85]

For communities forced to evacuate disaster zones, the impacts of such weather events may be especially severe and long-term. Storms and floods displace several million people every year by destroying homes and infrastructure.[86] Recent weather disasters have displaced millions of people in Myanmar, Mozambique, and Pakistan.[87] The most severe weather can cause catastrophic damage to infrastructure – roads, bridges communication lines, commercial premises, houses, and other buildings. It can also damage land and agricultural assets, in particular by destroying crops, decimating livestock, and contaminating soils with salt. Spring floods and autumn cyclones can be particularly damaging if they immediately precede or coincide with calving or harvest time.

The human toll is worst in the poorest and least resilient communities. Developing countries experience more than 90 percent of the fatalities caused by weather disasters. It's important to note that damage to infrastructure and other assets in poorer countries can be completely debilitating due to a lack of insurance coverage. Samoa lost 37% of its GDP to one cyclone.[88]

DEVELOPING COUNTRIES EXPERIENCE MORE THAN 90 PERCENT OF THE FATALITIES CAUSED BY WEATHER DISASTERS

WILDFIRES

Wildfires exact much less of a human toll. Their economic toll, however, while less than 3% of the total impacts of weather-related disasters, can have long-lasting effects. When fires approach populated areas, the impact can be devastating. Recent major fires in Australia, Greece, Spain, and Russia have caused significant casualties and damage.[89]

We cannot, with any confidence, blame any single storm, flood, or wildfire solely on climate change. But there is a plausible link between these events and what has been predicted by a number of climate change scenarios. Even if natural weather events are aggravated by climate change to a degree of only 5 or 10 percent, on a global scale that added stress could be immense. Like the straw that broke the camel's back, the added pressure of more frequent or higher intensity weather can make all the difference between a community that copes and a community in disaster. Given that highly effective measures exist to reduce disaster risk, policy makers have every reason to prepare for these new scenarios.

The number of documented fatalities from weather disasters surged in the 1990s (a rise that was at least partly due to improved reporting of casualties) but has fallen again since the start of the new millennium.[90] If Cyclone Nargis is removed from the 2000-2009 data, the last decade accounts for fewer than 100,000 such deaths. The drop in fatalities is mainly linked to improvements in disaster risk reduction introduced over this period. This means that fatalities are no longer a good stand-alone indicator of damage suffered by communities around the world. Hence this report also uses damage costs as a means of measuring impacts. Still, climate change does stress even good disaster reduction measures with its added risks.

Statistics covering weather-related economic damages are quite limited, so we have no universally useful record of damage costs

EVEN IF NATURAL WEATHER EVENTS ARE AGGRAVATED BY CLIMATE CHANGE TO A DEGREE OF ONLY 5 OR 10 PERCENT, ON A GLOBAL SCALE THAT ADDED STRESS COULD BE IMMENSE

due to weather disasters. Economic data is only gathered above a certain threshold. Because it is heavily based on insured losses, it does not accurately quantify the losses inflicted on the poorest communities, which rarely have insurance coverage. But there are also instances in which communities have exaggerated their losses in an effort to secure more external support.[91] For this reason, the Climate Vulnerability Monitor gives this data much less weight than fatalities when determining a country's vulnerability level. Fatality data is generally considered more sound. We urgently need a more effective method for estimating the possible economic losses that can have a significant effect on vulnerable communities – one based on case study examples, for instance.

LINKS FROM CLIMATE CHANGE TO IMPACT INDICATORS

CLIMATE CHANGE EFFECTS	PHYSICAL CHANGES	VULNERABILITIES	IMPACT INDICATORS
• Changes in local rainfall and river run-off patterns • Rising sea-levels • [Melting glaciers]	• Inland floods • Coastal floods	• Injuries • Access to clean water and food • Destruction of shelters and infrastructure	Impact of floods • Described as climate change impact on the number of deaths as share of population and as damage costs as share of GDP
• Rising surface temperatures	• Frequency and intensity of storms • Frequency and intensity of cyclones • Storm surges	• Injuries • Access to clean water and food • Destruction of shelters and infrastructure	Impact of storms • Described as deaths due to storms and as damage costs as share of GDP
• Rising temperatures • Changes in local rainfall	• Wildfires • Drought • Wind	• Injuries • Displacement • Destruction of property	Impact of vector-borne diseases • Described as deaths related to malaria and dengue due to climate change

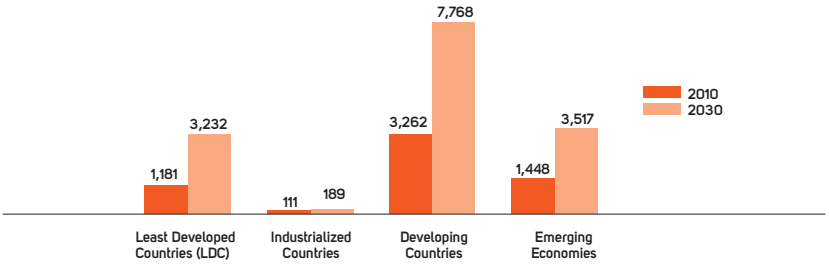
WHO SUFFERS?

Communities in the tropical and extra tropical regions are by far the most exposed to weather disasters. The worst-affected regions are the Caribbean, Central America, South America, South Asia, and Southeast Asia. The Pacific region suffers the highest damage costs.

THE SPREAD OF IMPACT: MORTALITY

The distribution of climate-related weather disaster mortality by socio-economic group in 2010 and 2030

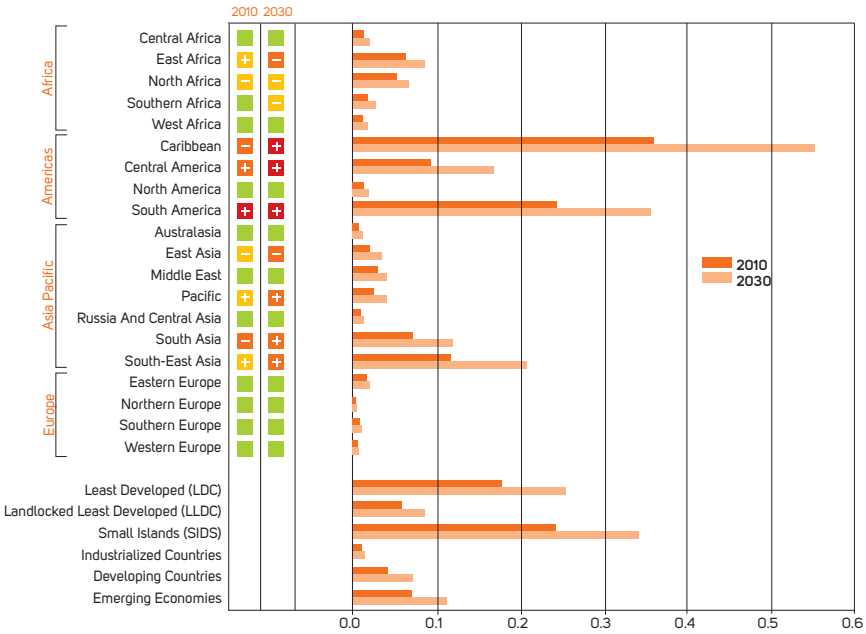
Additional Deaths average per year



A number of countries outside of the most-affected regions that have very low resilience also experience significant effects, including Somalia, Djibouti, and Afghanistan. Bangladesh is an example of a country severely affected by weather disasters that already has significant risk reduction measures in place that are likely preventing the worst effects.

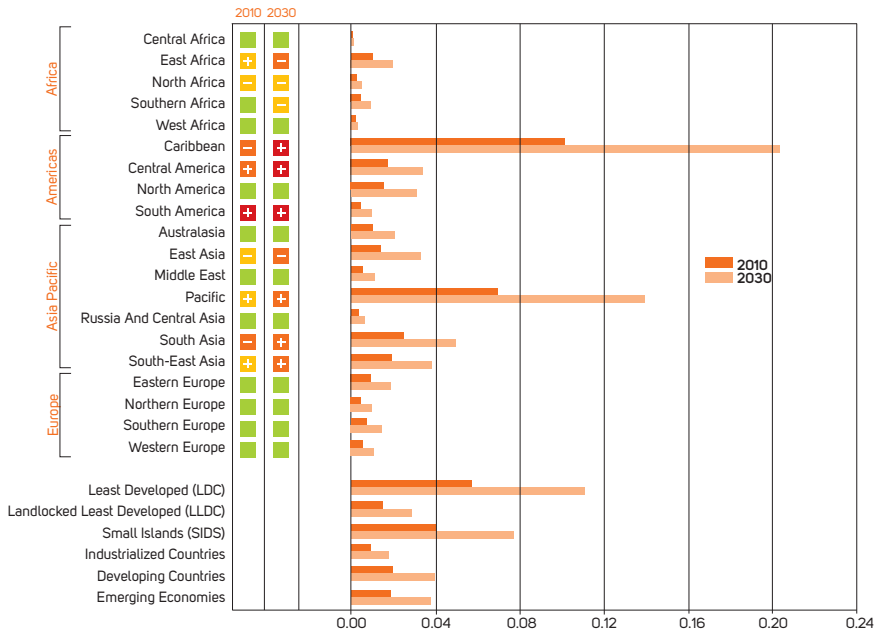
IMPACTS AROUND THE WORLD: MORTALITY

The regional and socio-economic distribution of additional deaths from extreme weather relative to population in 2010 and 2030
Deaths per 100,000, average per year



IMPACTS AROUND THE WORLD: DAMAGE COSTS

The regional and socio-economic distribution of climate-related damage relative to GDP in 2010 and 2030
Additional damage cost (percent of GDP)



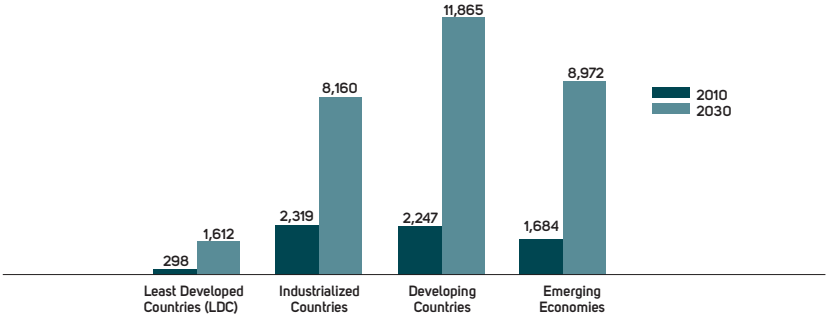
Venezuela tops the list of the worst-impacted countries. Venezuela has faced debilitating disasters over the past 20 years. However, it's possible that observations reported in the database used for the Monitor may exaggerate 1999 flood impacts in Venezuela by an order of magnitude.[92]

The projected excess deaths from weather disasters due to climate change are very concentrated among a small group of countries that are most acutely affected. Roughly 10 countries are projected to bear more than half the global deaths. The largest damage costs in absolute terms generally apply to the world's largest economies, with China and the United States projected to incur more than half the additional global damage due to climate change. But other countries, including Bangladesh and Iran, also face significant burdens.

THE SPREAD OF IMPACT: DAMAGE COSTS

The distribution of climate-related weather disaster damage cost by socio-economic group in 2010 and 2030

Additional damage cost (million USD PPP) average per year



Weather disaster impacts over the past 20 years provide us with key information for calculating these projections. They can point to trends in exposure to hazards and underlying vulnerabilities.

The Monitor gauges the impact of weather events in reference to the past number of reported fatalities a country has experienced. Another method of gauging impact is to look at the country's exposure to an event rather than at past damage. The 2009 Global Assessment Report on Disaster Risk Reduction, for example, used this approach to highlight all countries in the path of a disaster as exposed, whether or not high levels of fatality or damage had occurred. But exposure to weather disasters doesn't always imply vulnerability, and some countries in the path of a disaster will experience significantly greater losses than others for a variety of reasons.

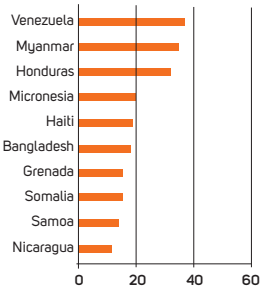
Although neither is the past necessarily the best indication of what is to come. But the Monitor, for example, does not highlight Cambodia, Vietnam, Philippines, and Fiji as highly vulnerable despite the fact that they lie in clear cyclone paths, since they have not registered high fatalities or damages during recent floods and storms -- which in itself is taken as indication that vulnerability is actually low in spite of high exposure. In a way, these countries may represent examples of good practice in disaster risk reduction, since each is in the clear path of danger but remains relatively untouched compared to other, similarly exposed countries.

It will be important to supplement the Monitor with methodologies that provide information about national-scale hotspots and hot weather systems and that can offer guidance to policy makers at the local level.

HIGH SURGE VULNERABILITY

Countries with the fastest growing climate-related weather disaster impact between 2010 and 2030

Percentage increase in climate-related weather disasters



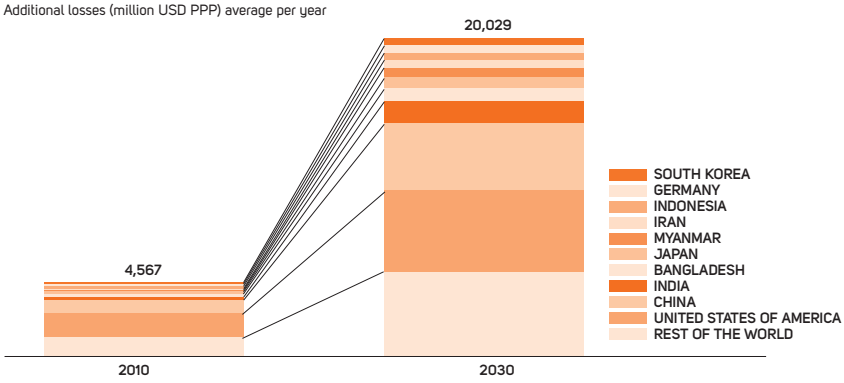
VULNERABILITY SHIFT

The change in the number of countries by each Vulnerability Factor between 2010 and 2030

Number of Countries by Vulnerability Factor

HOTSPOTS: DAMAGE COSTS

Countries with the largest total climate-related weather disaster by damage cost
Additional losses (million USD PPP) average per year



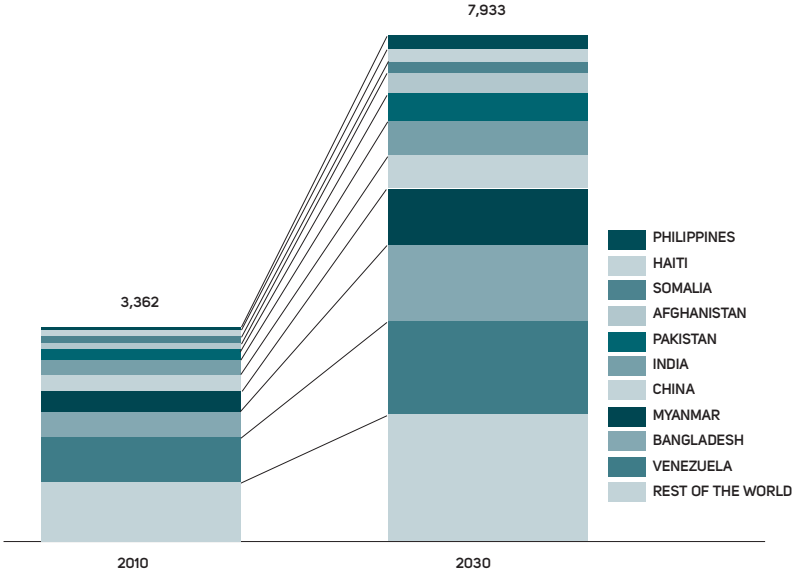
THE IMPACT TOMORROW: 2030

The Monitor projects that a relatively small number of countries will continue to suffer from the worst effects of weather disasters. Some 30 countries are projected to have severe or acute vulnerability factors by 2030.

Most of the worst-affected countries are also the countries where impacts are projected to rise the fastest between 2010 and 2030. However, Samoa and Nicaragua (currently not among the worst-affected) are examples of countries that are also projected to face significant increases in impacts.

HOTSPOTS: MORTALITY

Countries with the largest total climate-related weather disasters by number of deaths
Additional Deaths average per year



WORST HIT AND LEAST HIT (2030)

The top 10 countries worst and least affected by weather disasters related to climate change in 2030 relative to their size

WORST	LEAST
VENEZUELA	MARSHALL ISLANDS
HONDURAS	TUVALU
MYANMAR	SINGAPORE
HAITI	GABON
MICRONESIA	EQUATORIAL GUINEA
SOMALIA	BRUNEI
DJIBOUTI	PALAU
BANGLADESH	QATAR
GRENADA	SAO TOME AND PRINCIPE
AFGHANISTAN	KIRIBATI

SPOTLIGHT: SOUTH ASIA/STORM SURGE

The heaviest toll of weather disasters is extremely concentrated. Of the 1 million deaths due to floods, storms, and wildfires over the last 40 years, over 800,000 – or 80 percent – have occurred in just four countries, all of them in Asia: Bangladesh, China, India, and Myanmar. Half a million of those deaths have occurred in just one country: Bangladesh. Virtually all of the deaths that occurred in the next most affected country, Myanmar, occurred in the space of 24 hours when the country was struck by Cyclone Nargis in May 2008.[93]

Prior to 1960, China regularly experienced colossal weather disasters that claimed hundreds of thousands, even millions, of lives according to records.[94] In 1931, over 3 million people were killed in flooding, and over 2 million were killed in 1959. Since that date, China has lost a little more than 1,000 lives on average every year from these types of disasters, which for a country of over 1 billion people is extremely low. Hydroelectric power damns now prevent mass flooding of the country's main rivers, and modern disaster reduction practices have greatly limited fatalities due to typhoons. However, the recent Sichuan earthquake disaster has revealed a serious issue of construction integrity within China that predisposes much of the country to disasters of all kinds, including weather-related.[95]

Nearly all of the three quarter of a million deaths caused in the other three worst-affected countries over the last 40 years are attributable to just seven storms. The worst-affected areas of Bangladesh, India, and Myanmar also share five key characteristics: location in the tropics; extreme poverty; dense population; river deltas; and very low-lying land.[96]

The deadliest instrument of a cyclone is its storm surge, which is a swelling of the sea when storm winds helped by violent currents force water up against the shore.[97] When such a surge occurs at a riverhead, it meets with flooded waterways seething from massive amounts of cyclone-driven rain. Storm surge can reach over 5 metres or 18 feet in height and can rapidly engulf hundreds of kilometres of low-lying land. It is the cause of the lion's share of cyclone fatalities not only in Bangladesh, India, and Myanmar, but worldwide.[98]

The 2008 category 4 Cyclone Nargis that devastated Myanmar was an unexpected event, since the region has experienced a very limited number of storms of such scale in the past. No proper disaster alerts were issued to a population literally washed away without any advance warning.[99]

In India and Bangladesh, risk reduction has massively reduced fatalities due to these types of hazards over time. The category 3 Cyclone Bohla killed 300,000 people in Bangladesh in 1970 and still ranks as the deadliest single storm of all time. A more severe category 5 storm struck the same region in 1991 killing 140,000. By 2007, category 5 storms, such as Cyclone Sidr would claim just 4,000 lives. In the intervening period, the population of the country had more than doubled.[100]

The comparative impact of category 4 or 5 storms in neighbouring countries within half a year of each other is a clear testament to the effectiveness of contemporary risk reduction measures: Bangladesh (Sidr: 4,000 deaths) had such measures in place. Myanmar (Nargis: 130,000) did not.[101]

But all disaster risk reduction need not be artificially imposed. After experiencing the trauma of a large-scale disaster, communities may automatically adopt more cautionary practices. Still, the damage associated with storm surges can often only be avoided with extended advance warning, since massive swaths of populated coastal territory must be evacuated to higher ground. Without adequate monitoring and communication channels, no level of local practice could assist a population under imminent threat of a category 4 or 5 cyclone storm surge.

TROPICAL CYCLONE STRENGTH "SAFFIR–SIMPSON HURRICANE SCALE"

CATEGORY	**WIND SPEED** mph (km/h)	**STORM SURGE** ft (m)
FIVE	≥ 156 (≥ 250)	> 18 (> 5.5)
FOUR	131–155 (210–249)	13–18 (4.0–5.5)
THREE	111–130 (178–209)	9–12 (2.7–3.7)
TWO	96–110 (154–177)	6–8 (1.8–2.4)
ONE	74–95 (119–153)	4–5 (1.2–1.5)

Source: US National Hurricane Center

While early warning systems, such as emergency alerts, evacuation plans, crisis shelters, and other measures can save lives, it is much harder to prevent damage to infrastructure and land.[102] So while by the time of Cyclone Sidr Bangladesh had reduced the death toll by a factor of 35 compared with the 1991 cyclone, the economic damage of each was comparable at roughly USD 2 billion.[103] And similar swaths of arable land were once more contaminated with salt, destroying productive capacity in a land of much subsistence farming.

THE ASSESSMENT

The Monitor assesses vulnerability to weather disasters by applying climate change risk factors for floods developed by the WHO, and storms and wildfires to historical (1990-2009) national statistics of mortality (80% weighting) and relative damage costs (20% weighting). The climate risk factor for floods is higher than for storms or wildfires, reflecting a stronger scientific link between climate change and heavy rainfall and other flooding triggers.[104] The low weighting for damage costs reflects the lower quality and coverage of the base information.

The number of people affected or in need of aid as a result of disasters is not included as an indicator, because each country and extreme event is likely to come up with a different definition of "affected". Only those countries with a historical record of deaths and damage from floods, storms, and wildfires will register as vulnerable to any degree. Countries with higher registered impacts to such phenomena over the last 20 years will register higher factors of vulnerability, as past impact is deemed an accurate indicator of future impact, capturing both exposure to floods, storms, and wildfires, and the level of protection or underlying vulnerabilities. Mortality is assessed relative to total population, and damage costs are assessed relative to total GDP, so that vulnerability factors take into account the relative burden of impacts within a given country.

The methodology for assessing vulnerability to extreme weather is less robust than for the Health Impact section of the Monitor. This is mainly because the reporting quality of economic damage is poor across the board. But also because mortality in extreme weather has been significantly reduced in modern times and is therefore no longer the best indicator of generalized vulnerability. However, those most vulnerable to weather disasters still register high levels of mortality, and so the Monitor is accurate in identifying these highly vulnerable countries. The few countries with factors of Acute or Severe have all experienced significant loss of life as a result of extreme weather in recent years. Yet since mortality profiles are quite similar and low across the board, many countries register similar factors of vulnerability. Countries with significant economic damages as a result of floods, storms, and wildfires, however, will also have their higher vulnerability recognized by the Monitor despite having low levels of mortality in many cases.

Mexico (Moderate/Moderate) stands out in particular as a country whose vulnerability appears to be underestimated. On closer inspection, though, Mexico is a large country with a demonstrated ability to minimize loss of human life even in the most severe weather conditions. Mexico is located in the main tropical cyclone pathway of the southern Caribbean and has suffered dozens of devastating hurricanes in recent history. In 2005, the category 1 Hurricane Stan affected some 2 million people, killing 36, with unprecedented torrential rain that caused USD 2.5 billion in damage. A few weeks later, category 5 Hurricane Wilma, the most intense cyclone ever recorded in the Atlantic, affected 1 million people and claimed USD 5 billion in damage but only 7 lives. Over the last 10 years, 29 major tropical cyclones have claimed just 174 lives out of a total population of over 110 million people. The billions of dollars in damage caused is only a fraction of a trillion-dollar-a-year economy.[105] Mexico is a good example of how communities under heavy environmental and climate stresses can minimize impacts, in particular the loss of human life, even when millions of people are affected. While the damage to infrastructure caused by extreme weather is still high, financial risks can be covered through insurance, enabling affected communities to bounce back quickly from severe storms and flooding.

The United States (Moderate/Moderate) is another country with surprisingly low vulnerability to extreme weather in the Monitor. As with Mexico, this is mainly due to the sheer size of the country and its economy. But, again, it is also due to the minimal human casualties caused by major storms, which is the main base measure for the Monitor. The US has three times the population of Mexico and ten times its economy, so even the most expensive tropical storm in history (Hurricane Katrina caused USD 125 billion in damage) and the deadliest of recent US history (with over 1800 deaths) is simply dwarfed by the country's sheer size. Many of the most serious storms that have affected the US in recent years, such as hurricanes Charley, Dennis, Ida, Jeanne, and Rita have all claimed less than 10 lives each. Exceptionally deadly hurricanes by US standards, such as Allison (41 casualties), Ike (82), Ivan (52), Frances (47), and Gustav (43), are nevertheless significantly less deadly than weather disasters occurring in acutely vulnerable countries such as Bangladesh or Myanmar, which have claimed tens of thousands of lives.[106]

A series of small island states residing in known cyclone paths also find themselves with relatively low vulnerability factors of Moderate/Moderate; they include Barbados, French Polynesia, Kiribati, Marshall Islands, Mauritius, New Caledonia, Saint Lucia, Trinidad and Tobago, and Tuvalu. But all these countries combined have registered only 29 deaths from all storms and floods since 1990, demonstrating low vulnerability to loss of life from extreme weather. Mauritius aside, all combined recorded storms and floods over that time cost the other eight countries just USD 125 million (or about USD 700,000 per country, per year if averaged). Mauritius lost around USD 150 million in each of two major storms in the 1990s, but this was less than 2% of a USD 8 billion economy. Antigua and Barbuda (High-/Severe+), on the other hand, lost USD 400 million to Hurricane Luis in 1995, or almost two thirds of its annual GDP at the time.[107]

Venezuela (Acute+/Acute+) received the highest factor of vulnerability because the Vargas flood disaster of 1999 is recorded to have claimed 30,000 lives in a country of some 25 million people. However, a recent study has revealed that the reported death toll was inaccurate and that the actual death toll was likely not more than 700, which would result in a much lower factor of vulnerability for Venezuela. Since the Monitor's climate risk factor for floods is higher than for storms or wildfires, the Venezuelan Vargas flood anomaly has had a greater impact on its overall vulnerability factor. The example illustrates that the Monitor is highly dependent on historical data and relies on key data that varies widely in terms of quality.[108]

HABITAT LOSS

The often irreversible loss of human habitat to deserts and rising sea-levels are among the most vivid effects of the change in our climate. Increasing temperatures contribute to rising sea-levels and cause deserts to expand.[109] When summed up globally, today's slow, nearly undetectable changes to seashores and advances of arid lands and deserts ultimately affect millions of people. And these changes are relentless and accelerating. The poorest communities often feel the worst impact of these effects. And worst hit among them are low-lying countries, such as small island developing states, nations with large river estuaries, and communities living in arid zones or drylands.[110]

2010

CLIMATE EFFECT TODAY

3 MILLION

AT RISK FROM DESERTIFICATION

65 BILLION DOLLAR

SEA-LEVEL RISE IMPACT PER YEAR

2030

CLIMATE EFFECT TOMORROW

10 MILLION

AT RISK FROM DESERTIFICATION

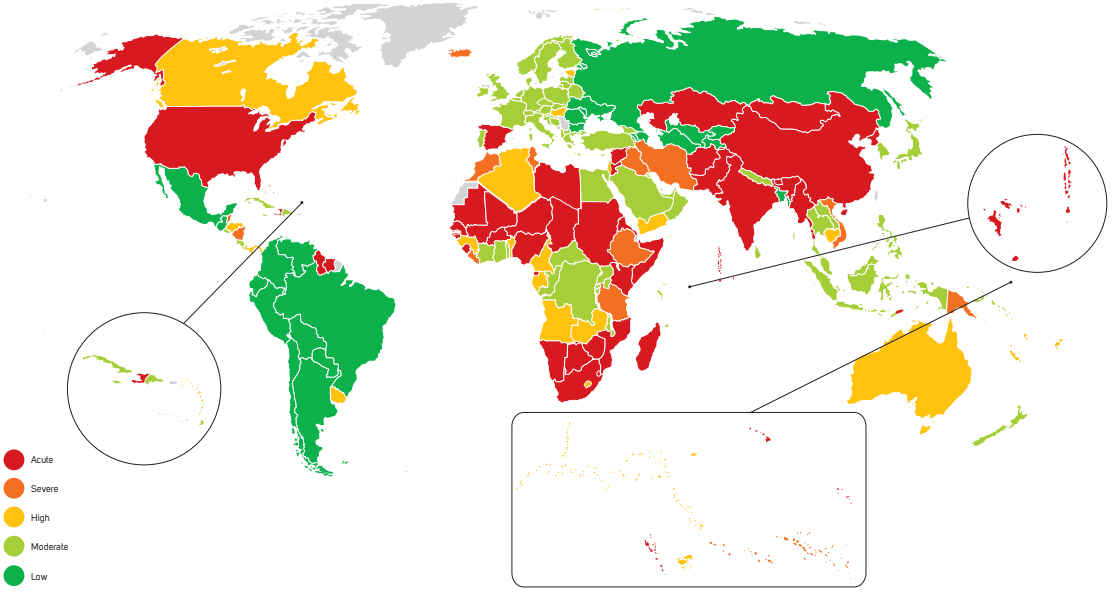
100 BILLION DOLLAR

SEA-LEVEL RISE IMPACT PER YEAR

FINDINGS

GLOBAL VULNERABILITY TO CLIMATE HABITAT LOSS

countries by overal climate vulnerability for habitat



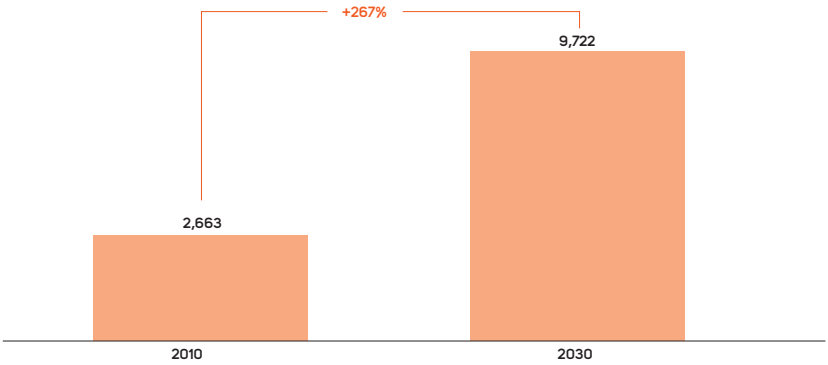
This chapter assesses the slow but devastating impact of climate change on environments where people live. The frontline of the struggle of people against damaged and vanishing lands is taking place at the borders of the world's growing deserts and on the shores of the world's rising seas.

Both desertification and sea-level rise are claiming land from people and passing on heavy costs to the communities affected. In the absence of significant countermeasures, more than 2 million people are estimated to be at risk of desertification due to climate change today. And that figure will rise to almost 10 million by 2030.

Climate change is the principal factor responsible for sea-level rise. The relentless stress caused by rising seas is systematically wearing down coastal areas and their communities in every part of the world.[111] Rising sea-levels are estimated to cause USD 65 billion in losses each year today, a figure expected to rise to almost USD 100 billion in losses each year by 2030 as coastal lands are quietly flooded, degraded, or completely submerged.

GLOBAL CLIMATE DESERTIFICATION IMPACT BURDEN

The change in the scale of global climate-related desertification population risks from 2010 to 2030
Total additional persons at risk of desertification (1000)

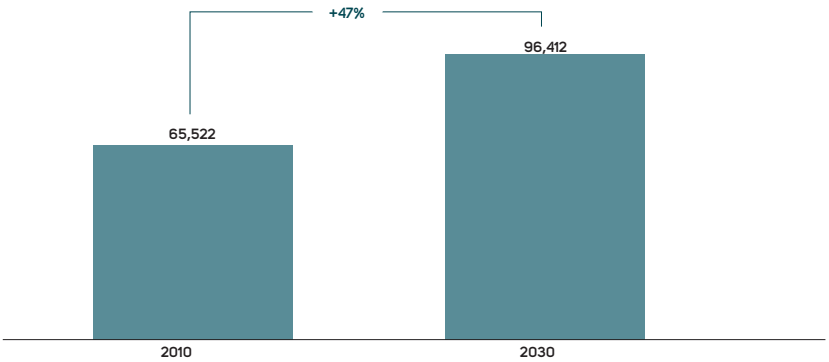


Developing countries are expected to experience the lion's share of these impacts. More than 80% of the impact of both desertification and sea-level rise is projected to hit developing countries through 2030. However, particularly in regards to sea-level rise, industrialized countries are also projected to face a significant burden in absolute terms.

Human habitats in two groups of countries are particularly vulnerable to the effects of climate change -- those in land-locked least developed countries (who face a dramatic threat of desertification) and those in small island developing states (who will be hit hard by the effects of sea-level rise).

GLOBAL CLIMATE SEA-LEVEL RISE IMPACT BURDEN

The change in the scale of global climate-related sea-level rise losses from 2010 to 2030
Additional losses (million USD PPP) average per year



Habitat loss here refers to human habitats. It refers to the loss of arable land due to desertification and to the loss of land for any human use as a result of sea-level rise. The serious effects of climate change on marine and other species will also impact human societies. We often use the term "habitat loss" to refer to these wider environmental concerns, but it should be noted that this report does not take the full scope of these concerns into account.

Climate change's role in desertification is quite different from its role in sea-level rise. Desertification is happening rapidly around the world. But climate is only one of many contributing factors to desertification. Overgrazing, over cultivation, exhaustion of local water resources, and deforestation are other serious drivers of the phenomenon.[112] Measures exist for stemming or even reversing desertification (such as soil conservation or reforestation) and protecting against sea-level rise (through heavy infrastructure such as sea walls). But such measures can be extremely costly per square km or mile of land saved or restored. The thought of protecting the world's 850,000 kms (550,000 miles) of coastline or the nearly 40% of the planet's land surface that are arid zones is almost overwhelming.[113] Focusing our efforts, however, could well mean relinquishing parts of the world's once habitable land for good.

IMPACT DYNAMICS

The scientific evidence for climate change and its key role in sea-level rise is well established.[114] The role of climate change in desertification is less well agreed upon due to the vast range of factors involved.[115] This chapter does not deal with the full range of human and animal habitats under threat, such as Arctic tundra lands, boreal forests, coral reefs, and tropical and temperate peat-lands. These are, however, covered to an extent in the Economic Stress section, where losses in biodiversity linked to climate pressures on these and other areas have been calculated in economic terms. Drought -- which is linked to desertification but is a separate climate phenomenon -- is covered in the health and economic sections of this report in relation to its impact on human health, agriculture, biodiversity, and water resources.

PEAK IMPACT HABITAT ▲

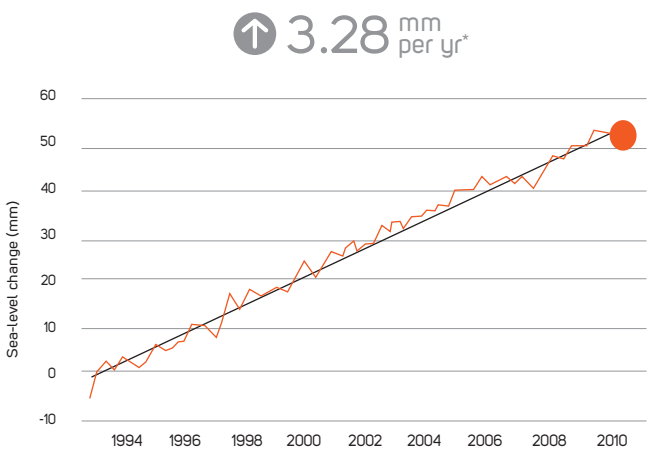
ONGOING	China- Gobi Desert	Desertification	Expanding at a rate of 3,600 km2 or 1,400 miles2 per year[116]
ONGOING	Sahel	Desertification	Expanding at the rate of 25 km2 or 9 miles2 per year[117]
1997	Tuvalu	Sea-level Rise/ Storm Surge	Cyclone destroyed an islet rendering it uninhabitable[118]
1999	Kiribati	Sea-level Rise	Lost two islets which disappeared underwater[119]
2008	Marshall Islands	Storm surge/ coastal flooding/ sea-level rise	Storm surge combined with high tides caused severe flooding. 10% of population was evacuated[120]
2008	Papua New Guinea	High Seas/ Coastal Flooding	75,000 affected in low-lying islands and coastal regions in 7 provinces[121]
2010	Bangladesh (Sunderbans)	Sea-level rise	South Talpatti, which was 210 km2 or 80 miles2, became the 5th island in the Sunderbans to sink[122]
2010	Thailand (Andaman Sea)	Coral bleaching event	Largest coral bleaching witnessed since 1998 - 95% of coral bleached[123]

SEA-LEVEL RISE

The world's seas have risen by 3.3mm (1/8 inch) every year over the last 15 years.[124] That amounts to one centimetre (just under a 1/2 inch) every three years, or 3-4 cm (1 inch) a decade. Over the course of the 20th century, sea-levels rose by around 20 cm. This century they will continue to rise faster still.[125]

RATE OF GLOBAL AVERAGE SEA-LEVEL RISE

Satellite sea-level observations



* estimate for 1993-2010

Source: NASA CLS/Cnes/Legos"

Sea-level rise is caused by two factors: Thermal expansion of warming water and fresh water influx due to melting land ice. The latter is estimated to be gaining momentum due to rising temperatures. Observations of the Greenland and Atarctica ice sheets indicate they are increasingly losing mass, and mountain glaciers are melting at an accelerated pace, according to observations. Estimates for the last five years indicate an 80% land-ice contribution to the observed global sea-level rise.[126] Both factors will continue to be affected and aggravated by rising temperatures even after global temperatures have stabilized, which means that sea-levels will continue to rise for many centuries.[127]

With rising temperatures, large ice masses become more vulnerable. Their potential contribution to sea-level rise is enormous. The Greenland ice sheet holds enough water to raise the global sea-level by up to 7 meters (23 feet). There is, however, currently no evidence from model simulations or observational data that suggests a near-complete disintegration might occur faster than on a multi-millennial time scale. Estimates of the Greenland ice sheet's maximum contribution to sea-level rise within this century amount to around 54 cm. The West Antarctic ice sheet in turn holds the equivalent of 5 meters, of which around 3 are potentially at risk of disintegration. Time scales for this amount of sea-level rise, however, are not available yet. Because the behaviour of ice sheets has not fully been understood to date and is not always accounted for in estimates of future sea-level rise, estimates vary from 18-59 cm to 215 cm of global sea-level rise by 2100.[128]

This growing rise in the world's seas affects coastlines everywhere. Higher seas have an erosion effect on coastlines, damaging shore life, property, infrastructure, and local ecosystems, all of which can be quantified. The lowest land areas can be completely submerged, in particular during high tides or brief surges in sea-levels caused by heavy

ALMOST 10% OF THE WORLD'S TOTAL POPULATION LIVE IN AREAS FROM ZERO TO JUST 10 METERS ABOVE SEA-LEVEL

storms.[129] Other important effects, such as salt contamination of soil and water supplies or heightened impacts from storms, due mainly to storm surge, are covered in the chapters on Weather Disasters and Economic Stress respectively. Damage to cultural assets, tourism, and transport systems are not readily quantifiable and have not been taken into account.

Almost 10% of the world's total population live in areas from zero to just 10 meters or 30 feet above sea-level, including many of the world's largest cities.[130] All these populations should be considered under great pressure due to climate change. However, the most vulnerable populations are those that cannot afford to build up land or sea walls to preserve against erosion, soil and water contamination, storm flooding, and total loss of dry land to the seas.

The 200-300 million people living in the rural areas of these zones in countries with High vulnerability or above should be considered potential climate migrants or displaced people. The economic losses that these rural and urban communities incur due to climate change are used as the indicator of impact in this report. We have based our estimates on the findings of a major international collaboration called DIVA (Dynamic Interactive Vulnerability Assessment), which calculates economic impacts caused by climate-driven sea-level rise all around the world.[131]

DESERTIFICATION

While over-grazing, over-cultivation, deforestation, and unsustainable use of water supplies are well documented as the main causes of desertification, climatic factors such as higher temperatures and stronger high winds, have a clear aggravating effect on the phenomenon.[132]

In many areas, including desertification-prone lands, temperatures can be as much as a year-long average of 5 degrees Celsius (9 degrees Fahrenheit) hotter than the norm.[133]

While the higher temperatures brought by climate change will increase rainfall in general (because higher temperatures intensify water evaporation), that effect will be isolated to specific areas. Most drylands and deserts will not benefit from the increase. In fact, shifting rainfall patterns are, in many cases, making already marginal arid zones even drier.[134]

A combination of continuous and extreme heat and lack of rainfall in already marginal arid lands gradually or abruptly kills off plants, trees, and other vegetation. That can push the local ecosystem into a vicious cycle as evaporation of remaining water or rainfall deposits increases due to a lack of shade. Soil salinity rises as water leaves the ground at pace, harming any new growth prospects. Unable to block out sunlight or heat during the day, or retain heat during the night, desert-like areas are plunged into repetitive hot-cold extremes that are hostile to most life-forms and that further discourage regeneration.[135]

Some areas of the world, such as the Horn of Africa, are experiencing recurring drought, which can force millions of people into crisis as ecosystems and rain-based water supplies completely collapse.[136]

But desertification occurs when degradation takes on a permanence that defies the natural or managed ability of a land to recover from drought when rains return. Arid land becomes desert, which is both difficult and costly to restore.[137]

Where degradation of arid or semi-arid regions is extreme, desert sand dunes can advance against little resistance, carried mainly by the winds. Desert expansion in some areas, such as the Gobi Desert, has reached an explosive 15 kms per year.[138] Dust storms, which can also assist the spread of infectious diseases, such as meningitis, are another hallmark of lands under threat from desertification.[139]

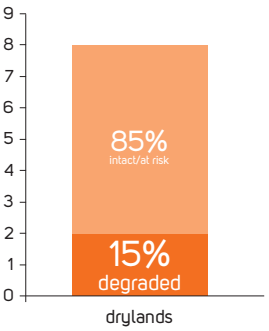
The harsh climate, ecosystem breakdown, lack of water and shade, and near irreversible degradation of land no longer fit for crops or grazing means most inhabitants have to uproot and leave.[140] More than 100 million people are living under pressure from desertification today, and that number is expected to significantly increase by 2030. These people should be considered potential climate migrants or displaced people. Not all desertified land creates migrants. It is possible for communities to persist in a desert environment, such as by benefitting from resources derived from peripheral land. But for most people, desertification implies abandonment of land and property.[141] Those who remain become even more vulnerable.

This report bases its findings on the PLACE II database (Population, Landscape, and Climate Estimates), which is managed by the Earth Institute of Columbia University, New York, and draws on US government observational information.

DESERT EXPANSION IN SOME AREAS, SUCH AS THE GOBI DESERT, HAS REACHED AN EXPLOSIVE 15 KMS PER YEAR

GLOBAL DESERTIFICATION

Percentage of degraded drylands (million sq km)



Source: Millenium Ecosystem Assessment; CIA Factbook

LINKS FROM CLIMATE CHANGE TO IMPACT INDICATORS

CLIMATE CHANGE EFFECTS	PHYSICAL CHANGES	VULNERABILITIES	IMPACT INDICATORS
• Rising sea-levels	• Shore retreat • Salinization • Back-water flooding	• Loss of wetlands • Loss of dry land • Protection cost • Migration cost	Impact of malnutrition • Described as deaths related to malnutrition and lower respiratory infection due to climate change
• Desertification	• Rising surface temperatures • Droughts • Water pressure	• Access to water for human and industrial use • Food – agricultural yields, species • Extreme heat • Wildfires • Conflicts (pastoral – Horn of Africa, northern Uganda and northern Kenya)	Loss of human habitat due to desertification • Described as climate change impact on the share of population living in climate zones at risk of desertification

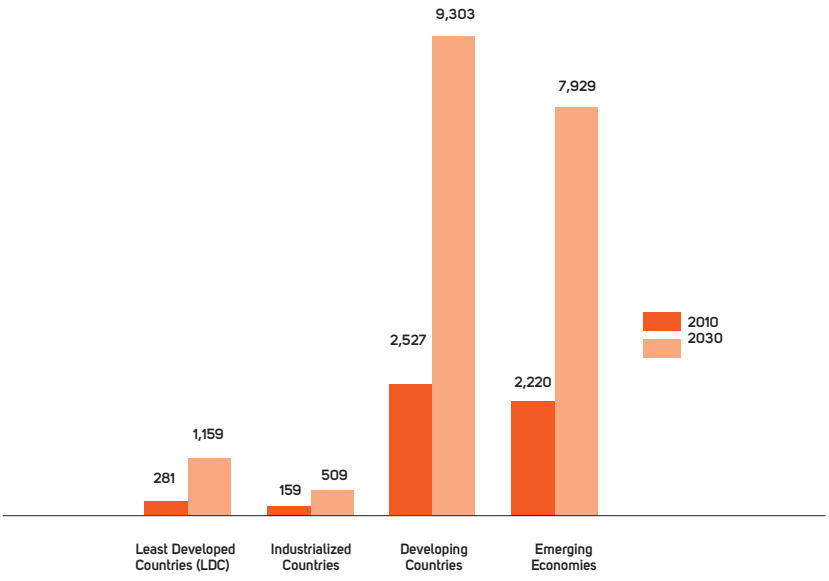
WHO SUFFERS?

Overall, the regions worst affected by habitat loss are Western Africa, Southern Africa, and the Pacific, followed by South Asia. The whole continent of Africa is among the most vulnerable.

THE SPREAD OF IMPACT: DESERTIFICATION

The distribution of climate-related desertification population risk by socio-economic group in 2010 and 2030

Additional persons at risk of desertification (1000s) average per year



The Pacific, the Caribbean, and Eastern and Western Africa are worst affected by sea-level rise.

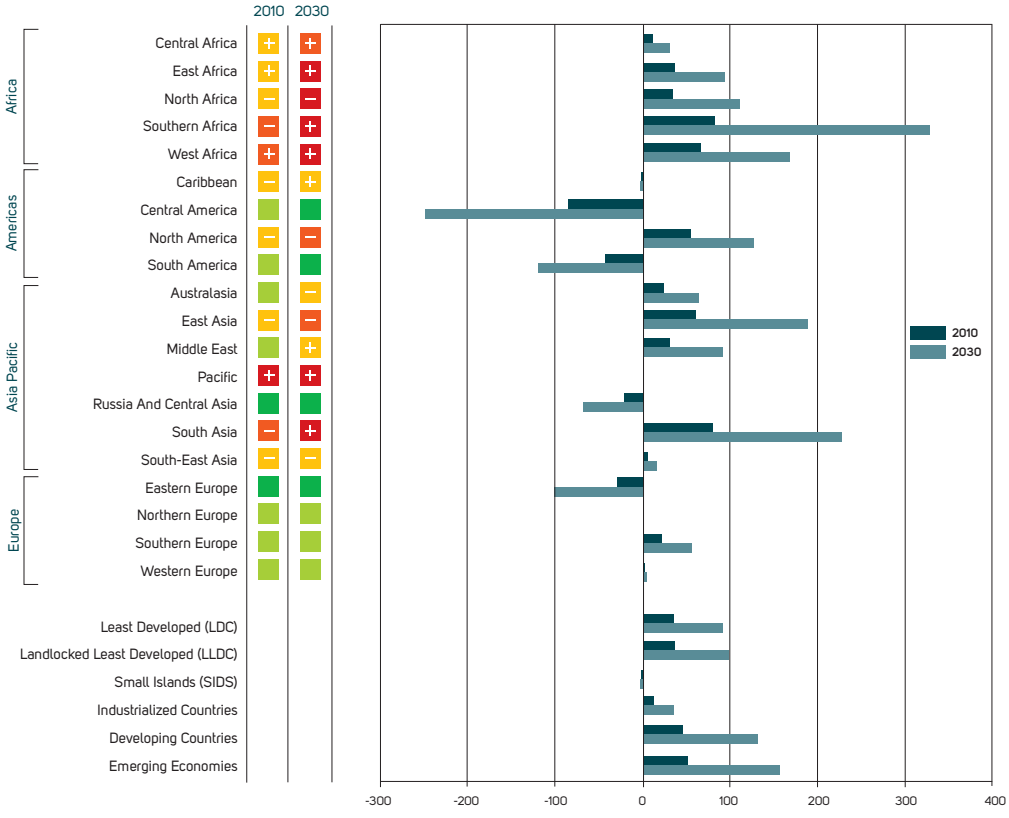
South Asia, Southern Africa, North Africa, North America, and East Asia are worst affected by desertification.

The countries projected to face the worst impacts of desertification are Botswana, Namibia, and Senegal. Namibia is the only country that is among the worst-affected by both desertification and sea-level rise.

The countries projected to face the most overwhelming impacts of sea-level rise are all small island developing states and countries in Africa. Guinea-Bissau is the country most vulnerable to sea-level rise. The river delta nation bordering on the Western Sahara Desert is projected to suffer extreme stresses. The losses that these countries are projected to incur correspond to a large share of their GDP each year. Large archipelagic countries, such as the Philippines, have not registered vulnerability as high as would be expected. This is because, statistically speaking, we calculate a lower vulnerability for countries with a lower ratio of coastline to overall land area than, for example, nations with proportionally more land area close to the sea, or higher levels of population and infrastructure clustered in low-lying coastal areas, such as the Maldives or Guinea-Bissau.

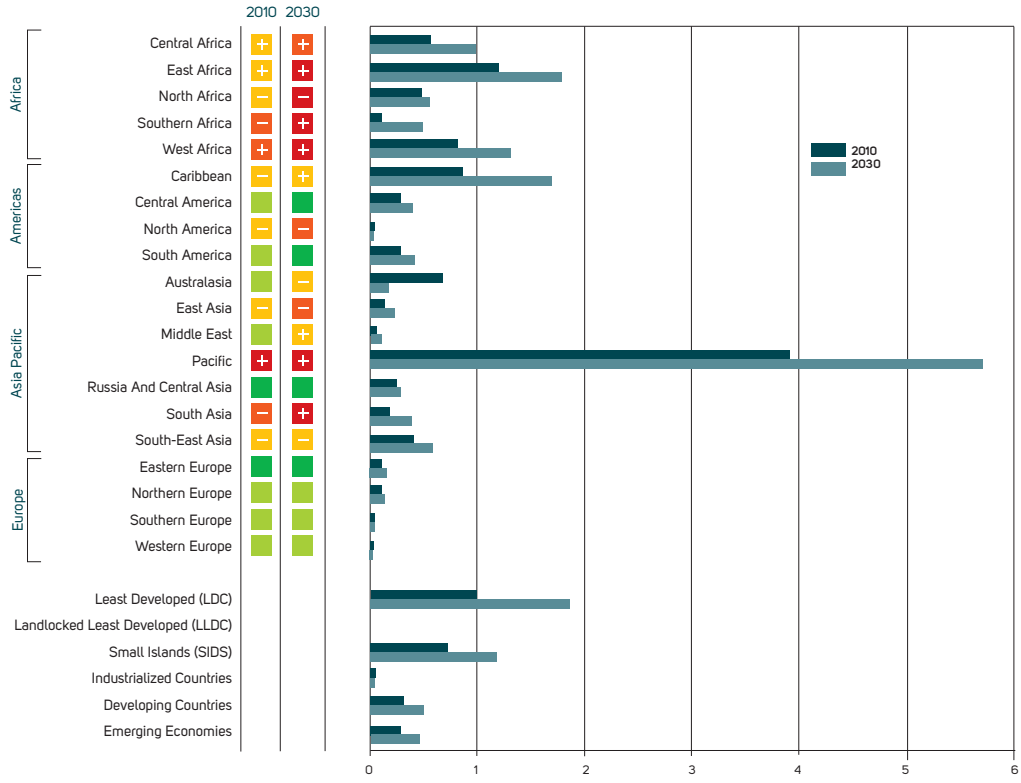
IMPACTS AROUND THE WORLD: DESERTIFICATION

The regional and socio-economic distribution of climate-related additional persons at rist of desertification relative to population in 2010 and 2030
Additional persons at risk per 100,000



IMPACTS AROUND THE WORLD: SEA-LEVEL RISE

The regional and socio-economic distribution of sea-level rise costs relative to gdp in 2010 and 2030
Additional losses (percent of GDP)



By evaluating impacts in these relative terms, we are best able to make comparisons across countries and points in time. And because these impacts are assessed in relation to local populations and levels of income, they are not skewed by different sizes of populations and levels of economic activity. Relative indications of economic losses are also more comparable between poor and wealthy countries because they take into account a country's underlying per capita income level. However, this "equity weighted" expression of economic impacts does not go as far as some indices in expressing the high vulnerabilities of the poorest communities around the world.

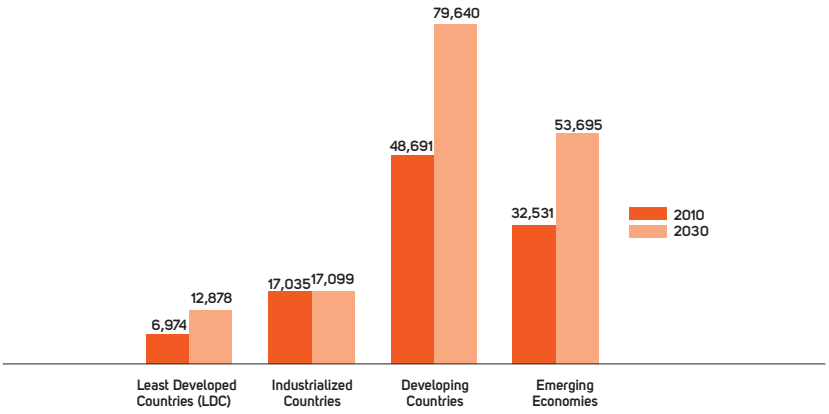
It is also important to note that estimates of absolute impact in 2010 and 2030 may increase both due to increases in climate change impacts and due to population and economic growth.

In absolute terms, 80% of the excess persons at risk due to desertification in 2030 are projected to live in China and India. The 10 countries with the largest populations at risk to desertification due to climate change bear almost the entire global burden. Among developed countries, the United States and Spain are the worst-affected in absolute terms.

China and India are also the countries projected to face the largest absolute economic losses due to sea-level rise. Other countries in Asia and Latin America, as well as the United States and Russia are also projected to suffer significant losses. Overall, the 10 worst-affected countries in absolute terms bear about half of the global economic losses caused by sea-level rise.

THE SPREAD OF IMPACT: SEA-LEVEL RISE

The distribution of climate-related sea-level rise losses by socio-economic group in 2010 and 2030
Additional economic losses (million USD PPP) average per year



A number of countries are protected from the habitat loss impacts described in this chapter because they are neither on the sea nor have dryland areas. In Asia, examples of these countries are Laos and Nepal; in Africa, Burundi and Rwanda; in Europe, Austria, Belarus, Czech Republic, Slovakia, and Switzerland.

The least-affected countries are in regions where a reversal of desertification trends is projected. These projections suggest that there are countries in Central Asia and Latin America that could experience benefits in terms of desertification.

THE IMPACT TOMORROW: 2030

Roughly 20 countries are severely or acutely impacted by habitat loss today, and that number is set to rise to 25 by 2030 (note that a number of small island states are not included among the 184 countries covered in this report due to a lack of data in a number of areas). Some of the lowest-lying areas are found in wealthy countries such as the Netherlands or the United States. North America, Australia, and parts of Mediterranean Europe are also home to some of the world's most arid regions. However, the key measure of vulnerability is whether a country must suffer through the changes as opposed to fending them off through significant investments. This is why wealthier nations are rated as less vulnerable than poor countries even where they may face similar impacts.

The regions projected to face the worst habitat losses between 2010 and 2030 are North Africa and the Middle East. In that same time period, South Asia and Southern Africa both move from High to Acute factors.

Several countries will experience a significant acceleration of exposures to habitat loss impacts between today and 2030. The deterioration in these countries, mainly in Asia and Africa, is primarily driven by desertification.

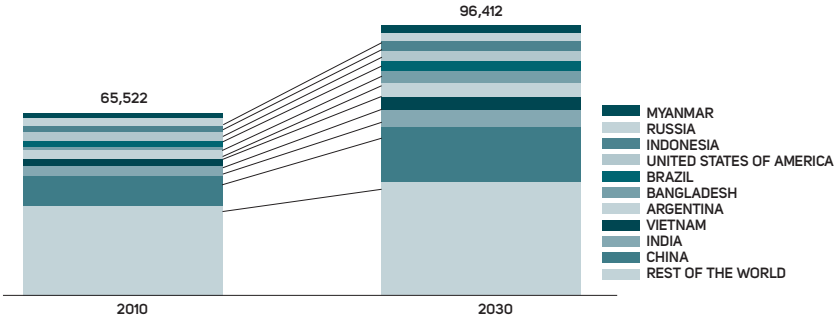
WORST HIT AND LEAST HIT (2030)

The top 10 countries worst and least affected by habitat loss related to climate change in 2030 relative to their size

WORST	LEAST
GUINEA-BISSAU	AZERBAIJAN
NAMIBIA	TAJIKISTAN
KIRIBATI	VENEZUELA
MARSHALL ISLANDS	TURKMENISTAN
MALDIVES	UZBEKISTAN
BOTSWANA	MEXICO
SOLOMON ISLANDS	KYRGYZSTAN
SENEGAL	PERU
TUVALU	COLOMBIA
SOMALIA	UKRAINE

HOTSPOTS: SEA-LEVEL RISE

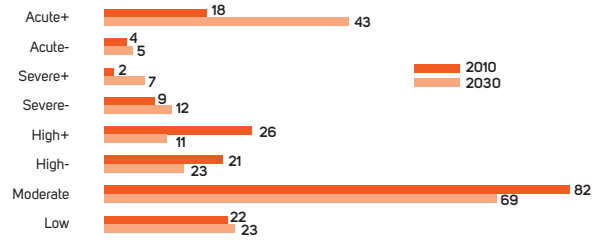
Countries with the largest total climate-related sea-level rise losses
Additional losses (million USD PPP) average per year



VULNERABILITY SHIFT

The change in the number of countries by each Vulnerability Factor between 2010 and 2030

Number of Countries by Vulnerability Factor

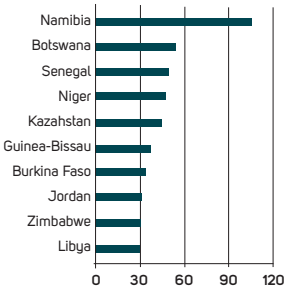


A group of already-vulnerable Western and Southern African countries are projected to be among the worst-affected by incremental habitat loss due to climate change between 2010 and 2030. Countries with large populations living in drylands outside Africa will also face accelerating stresses, including Kazakhstan, Jordan, and Libya.

HIGH SURGE VULNERABILITY

Countries with the fastest growing climate-related habitat loss between 2010 and 2030

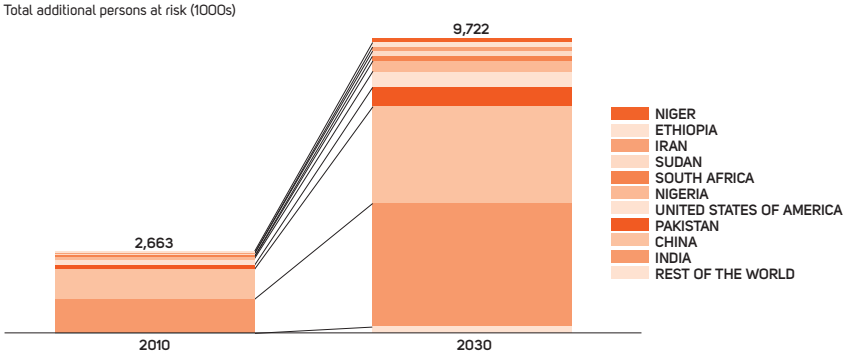
Percentage increase in climate-related habitat loss



HOTSPOTS: DESERTIFICATION

Countries with the largest total climate-related desertification population risk

Total additional persons at risk (1000s)



SPOTLIGHT: MULTIPLE HABITAT STRESS

Most countries are either affected by sea-level rise, or by desertification, or by neither. Desertification is usually a continental problem, since the centres of landmasses are less regulated by the constant temperatures of the sea, and can experience greater hot and cold extremes. In fact, many countries badly affected by desertification are landlocked states like Botswana, Niger, or Kazakhstan. Sea-level rise, of course, only stresses coastal areas. Nevertheless, a handful of countries, mainly in Africa, are badly affected by both sea-level rise and desertification -- in particular, Eritrea, Mauritania, Mozambique, Senegal, and Somalia. Outside of Africa, countries like Myanmar and Australia are also suffering from both stresses.

Countries affected by sea-level rise and desertification are fighting a battle on two fronts. Each of these stresses has quite different effects and requires very different responses, although both can involve the temporary or permanent disappearance of human habitats, and either could lead to displacement and migration of people to higher, more protected or less stressed lands. Sea-level rise particularly affects the economy through lost investment opportunities. Investments are instead spent on maintaining costly coastal infrastructure and protecting lands and communities at risk from inundation. Desertification reduces the land area available for agricultural purposes or human habitation. Most of the African countries suffering both types of impacts have low-lying coastlines and territories that back onto the Sahara Desert. Australia is a continent unto itself containing deserts and one of the largest coastlines in the world, which make it highly vulnerable to both those effects.

The compounded growth of this double pressure could sap significant economic and environmental potential from the affected countries, and so demands an intensive coordinated response. If no action is taken, people and communities will be increasingly endangered or forced to relocate. Either way, in the absence of external support, these pressures will very likely hold back socio-economic progress in some of the world's poorest countries. In the case of Somalia, this dual threat adds further complex stresses to its extreme fragility.

THE ASSESSMENT

The Monitor assesses loss of human habitat through climate-change driven desertification, or the degradation of dryland areas, via satellite-based mapping of land degradation evident (from the PLACE II database)[142] and a climate model (called IMAGE) that ascertains a likely aggravating role of climate change.[143] The indicator used is the population at risk from desertification. The indicator is fairly robust, since countries with a high factor of vulnerability will all have relatively large land-degradation problems verified by satellite imagery, and we can assess where this degradation appears to be worsening due to the effects of climate change. The Monitor assesses populations at risk relative to total population and assesses economic costs of sea-level rise proportional to total GDP to take into account the relative importance of these impacts for a given country.

The Monitor assesses loss of human habitat through sea-level rise via a complex global satellite-based model, DIVA, that calculates the cost burden on communities in coastal areas around the world.[144] Since it is based on satellite imagery, the indicator is fairly robust in conveying physical vulnerabilities. The model then weighs in the scale of exposure and costs of ongoing stress to communities in different coastal areas as lost GDP potential.

Despite its robustness, some results are surprising. Countries of the Arabian Peninsula, for example, such as Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, and Yemen, all share Moderate factors of vulnerability. None are deemed to be suffering impacts of desertification, since their environment is either already classed as desert or as urban or otherwise, but not as dryland-facing-degradation. Neither do any of these countries register any significant sea-level rise vulnerabilities.

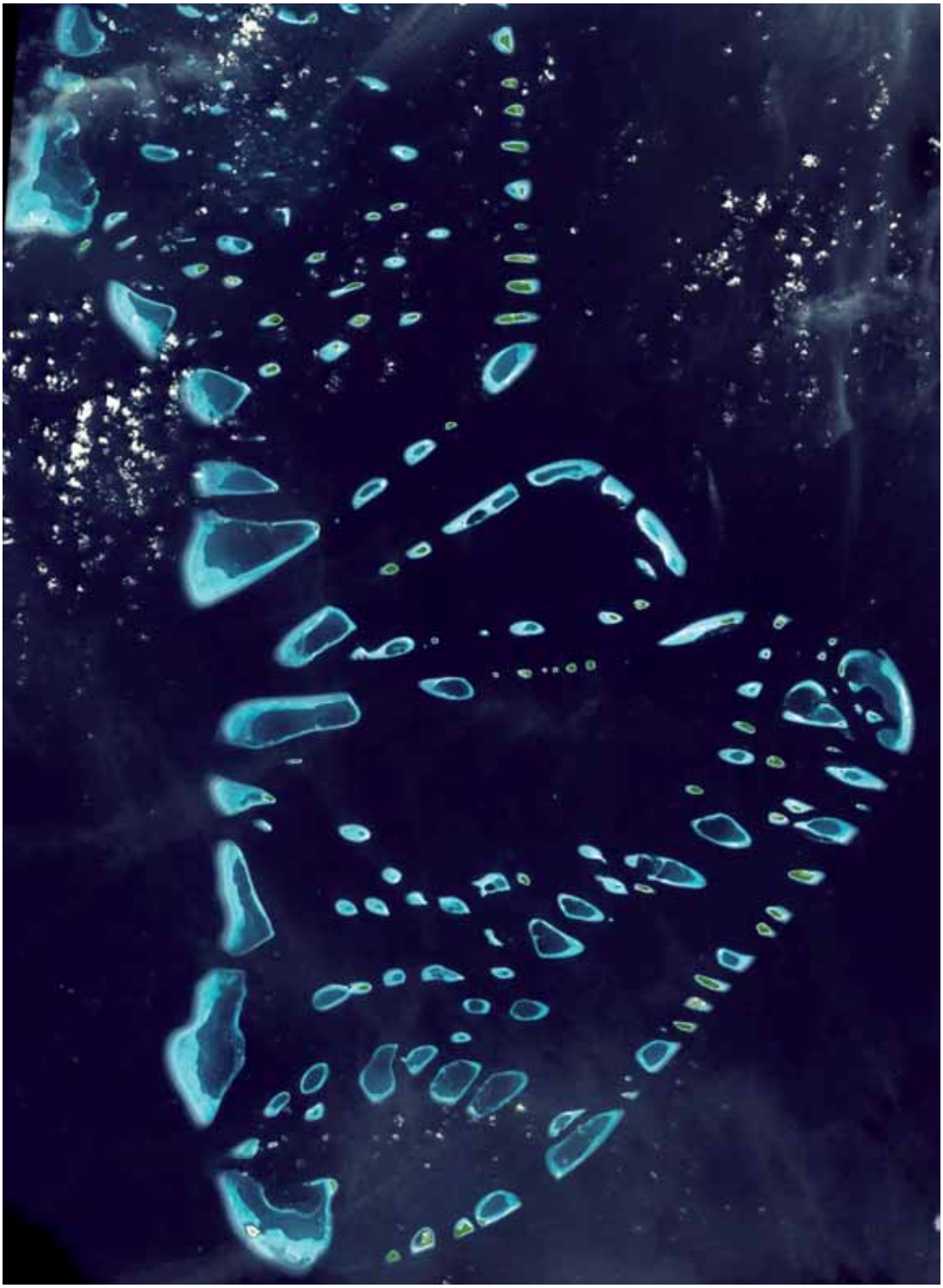
Bangladesh (Moderate/Moderate) is well known for its populous, low-lying coastal delta, but it is far less vulnerable than many other countries for reasons of scale. Bangladesh's coastline is just 580 kilometres or 360 miles long. Less than 15% of the country's population of more than 160 million people live in coastal areas below 5 metres (16 ft) altitude.[145] This compares with 100% for more vulnerable countries like Kiribati, Maldives, and Tuvalu. Bangladesh is also almost 500 times larger than Maldives in terms of total land area, with most of its territory well inland from the sea.[146] Similar rules apply to the Philippines (Moderate/Moderate). Despite having the fifth largest coastline on the planet, the Philippines has much less of its population in coastal areas below 5m/16ft than Bangladesh. Meanwhile, Canada (Moderate/Moderate) has similar vulnerability to Bangladesh and Philippines by virtue of possessing by far the largest coastline in the world (some 30 times that of the Philippines or more than 15,000 times that of Bangladesh), despite the fact that it has minimal populations living in low-elevation coastal zones.[147]

Scale also plays a role in comparative vulnerability to desertification. So when a compact country like Bhutan (High+/Acute+), which is roughly the size of Switzerland, suffers from growing degradation of its savannah and steppe-type lands, proportional pressure on its inhabitants is much higher than in huge countries like Algeria (Moderate/Moderate), where populations are far less concentrated around at-risk areas.

In Africa, the Central African Republic (Moderate/Moderate) has already suffered limited desertification but does not suffer from water stress extremes and should continue to receive more rainfall as a result of climate change (as will much of Central Africa).[148] Neighbouring Cameroon (Moderate/High-), however, is worse off, particularly where its northern border once met the now almost completely vanished Lake Chad. And heavily-populated Sudan (High+/Acute+) is set to suffer increasing degradation of its dryland regions along the margins of the Sahara Desert as temperatures continue to rise.

Four highly-developed countries register high factors of vulnerability to habitat loss: Australia, due mainly to desertification; Iceland, due to sea-level rise alone; Spain, due exclusively to desertification; and the United States, also due in particular to desertification. Iceland (High-/High+) has quite a small population (around 300,000) but a long coastline, similar in size to Argentina's. Almost all of its inhabitants live within 100 kilometres (60 miles) of the sea, which amplifies socio-economic vulnerabilities to growing coastal stress. In Spain (High-/Acute+), existing stresses on water supplies run headlong into less rain and more heat brought by climate change. While Australia (Moderate/High+) and the United States (High-/Acute-) are home to some of the largest dryland areas on the planet, both of which are becoming hotter and dryer as the planet warms up. Parts of the US, in particular, key areas of Southern Florida, are of very low elevation, so local vulnerability to rising seas is high. Nationwide, however, the US does not suffer sea-level rise impacts compared to those experienced by island nations or countries like Guinea-Bissau whose geographies are dominated by large river deltas.

Netherlands (Moderate/Moderate), one of the lowest lying countries in the world -- Half of the country lies below 1 meter (3ft) above sea-levels including one eighth of the country lying below sea-level -- has a surprisingly low levels of vulnerability to habitat loss /sea-level rise. Netherlands, however, is also one of the best prepared countries in the world in dealing with sea-level rise through robust protective measures such as dams, polders, dykes and dunes. The low-lying geography of the Netherlands has long dominated the country's development, with key infrastructure already long in place to allow for the productive use of below-sea-level coastal zones. The Netherlands does therefore not have to yet react to the same degree to protect its resources from coastal erosion or the dangers of sea-level rise to any significant extent when compared with other seriously affected countries. Adaptation to sea-level rise for the Netherlands may only imply in most cases an incremental reinforcement of existing infrastructure. Nevertheless, the total costs of this adaptation can be very large in absolute terms, but are small in size when compared with the overall scale of the Dutch economy -- one of the 20 largest economies in the world.



The Maldives archipelago, seriously affected by sea-level rise. Source: NASA/GSFC/METI/ERSDAC7JAROS, and U.S./Japan ASTER Team

ECONOMIC STRESS

Many economic sectors are sensitive to climate, just as many diseases are. While in the short to medium term some regions will reap benefits from warmer weather, overall, the additional stress of climate change will harm economic output and growth. It will also contribute to worsening global inequalities, since the economic impacts of climate change are, in general, most disadvantageous to the poor and most advantageous to the wealthy. The primary sectors of the economy are most sensitive to climate change, in particular agriculture, crops, livestock, and fisheries. Valuable environmental assets such as coral reefs, alpine rainforests, and species are also impacted negatively by global warming.

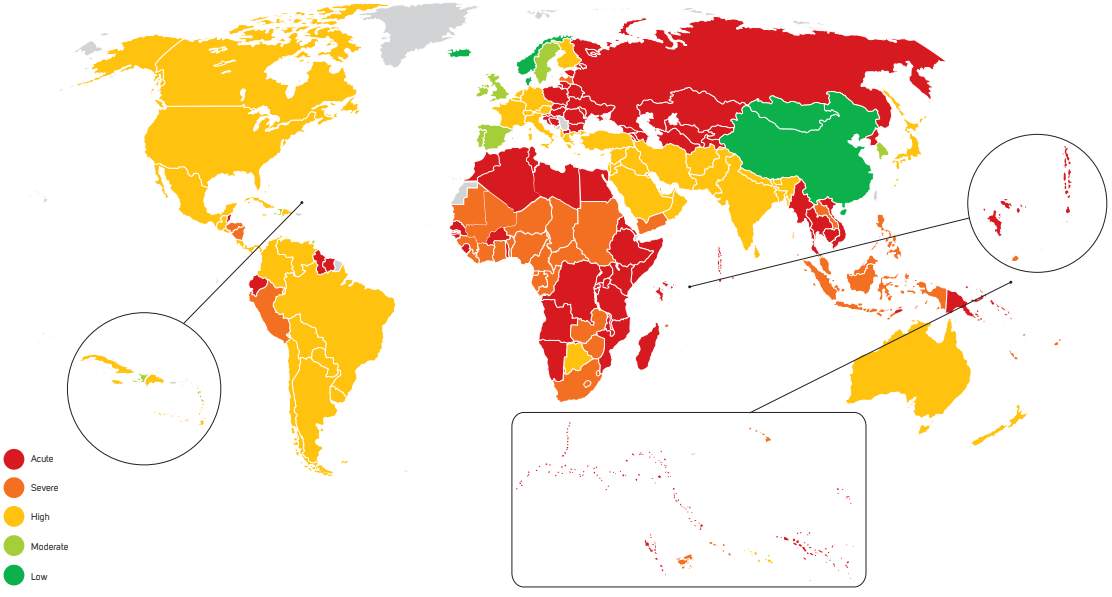
2010
CLIMATE EFFECT TODAY
65 BILLION DOLLAR IMPACT PER YEAR

2030
CLIMATE EFFECT TOMORROW
160 BILLION DOLLAR IMPACT PER YEAR

FINDINGS

GLOBAL VULNERABILITY TO CLIMATE ECONOMIC STRESS

Countries by overal climate vulnerability for economic stress



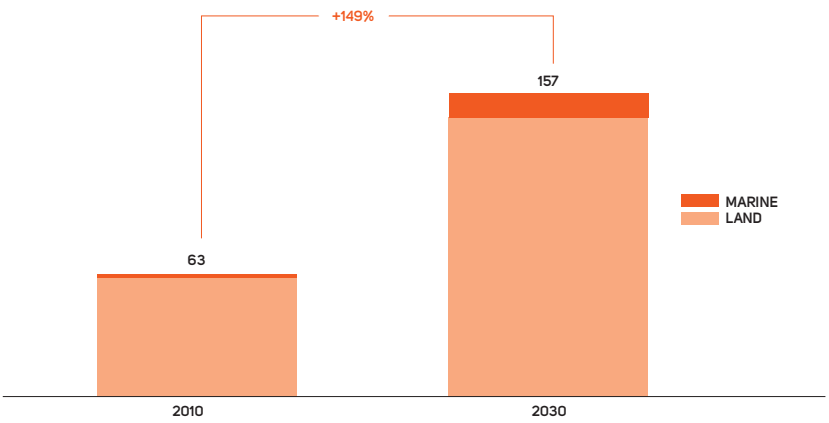
This section focuses on the incremental economic stresses climate change is placing on productive sectors in the economy. These economic losses occur in addition to the climate change impacts described in other chapters of this report, such as the immediate damage costs of extreme weather and economic losses due to sea-level rise.

These economic stresses are set to significantly widen the gap between wealthy and poor. In most cases, the economic impacts of climate change are actually making the rich richer, for example in some sectors of Northern Europe. The worst losses are being felt in countries that are already poor, especially in Africa, Central Asia, and Southeast Asia.

Globally, estimated economic stresses due to climate change point to losses of USD 63 billion each year today. This impact will rise by more than 100% to USD 157 billion each year by 2030.

GLOBAL CLIMATE ECONOMIC STRESS IMPACT BURDEN

The change in the scale of global climate-related economic losses from 2010 to 2030
Additional Economic Losses (billion USD PPP)



The economic stress due to climate change captured in this report is primarily based on primary sectors such as fisheries, forestry, and other agricultural losses or gains. It is to a great extent driven by water resource impacts and climate effects on biodiversity.

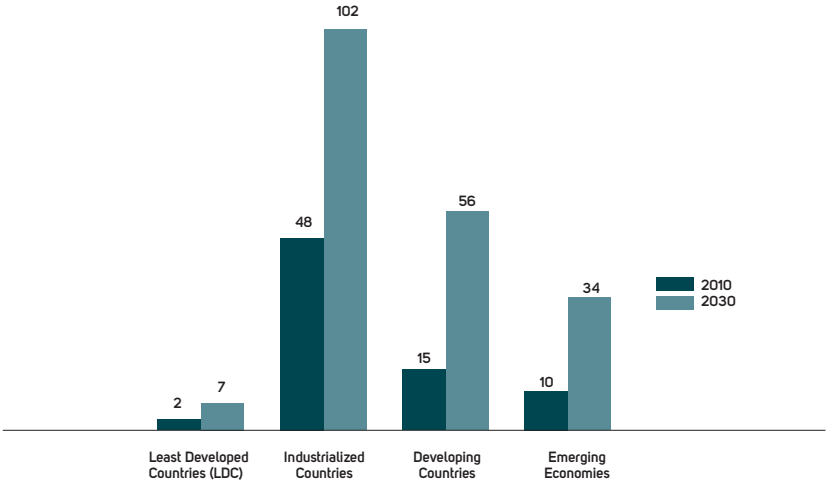
The estimates of economic stresses expressed here provide only a partial picture. Other important economic sectors are likely to be affected by climate change, including energy, tourism, and other service sectors, but good estimates are not yet available for many countries. The national and regional estimates provided here also often fail to capture the exposure of communities within countries that are particularly impacted by climate change. There is an urgent need to study these impacts in greater detail, particularly in developing regions that currently have the poorest access to such information. Still, the available projections provide a good barometer for economic impacts that will also be felt across other sectors of the economy.
More than half the total losses due to economic stresses brought on by climate change will be in industrialized countries. Large developing countries will also bear a significant burden. Least developed countries experience much harder impacts relative to the size of their economies, but since the GDP of lower-income countries is by definition much smaller, their impacts also contribute less to overall global losses. Projected economic losses are set to grow significantly between 2010 and 2030, both due to the increasing impacts of climate change and due to the projected underlying economic growth. Roughly half of the projected increase of 150% is explained by climate change and the rest by the underlying economic growth.

MORE THAN HALF THE TOTAL LOSSES DUE TO ECONOMIC STRESSES BROUGHT ON BY CLIMATE CHANGE WILL BE IN INDUSTRIALIZED COUNTRIES. LARGE DEVELOPING COUNTRIES WILL ALSO BEAR A SIGNIFICANT BURDEN

THE SPREAD OF IMPACT: ECONOMIC LOSSES

The distribution of climate-related economic losses by socio-economic group in 2010 and 2030

Additional Economic Losses (billion USD PPP) average per year



IMPACT DYNAMICS

The climate is changing. Temperatures are higher, rainfall is decreasing in some places, increasing in others, and the atmosphere carries more energy and humidity, bringing more wind and more uncertainty.[149] These changes will stress communities around the world in ways that impact economic values. Some communities will benefit overall, some will suffer overall, but all communities are likely to experience stresses that reduce economic growth as the environmental change brought about by global warming intensifies.

PEAK IMPACT ECONOMIC STRESS ▲

1999-2001	Iran	Drought	37 million affected- $3.3 billion in damages[150]
2000	Australia	Locust Infestation	Largest outbreak recorded - $120 million in damages[151]
2002	India	Drought	300 million affected - $910 million in damages[152]
2002	United States	Drought	$3.3 billion in damages[153]
2004-2005	Brazil	Drought	$1.65 billion in damages[154]
2006	China	Drought	18 million affected- economic damage of $2.9 billion[155]

Our planet's climate has changed dramatically over its billions of years of existence. In the last 650,000 years, there have been seven distinct ice ages – two since the emergence of people (homo sapiens) some 200,000 years ago. The last ice age ended around 10,000 BCE. Modern civilization emerged during the interglacial (or warmer) period since then, and for much of this time a relatively stable climate has been the norm.[156] The rapid

warming in global temperatures by almost 1 degree Celsius or 1.8 degrees Fahrenheit since the 1900s represents a pace of change on a level that is unusual in nature and completely unprecedented for human civilization. And this rate of change is rapidly accelerating as we continue to pollute the earth's atmosphere.[157]

Over long time periods, the earth would adapt to the changes thrown at the environment. Coral reefs may die out in the warmest waters but grow in colder -- warming -- waters, which might present a more favourable habitat. Water may drain from one part of the world and accumulate elsewhere.[158] However, the costs of such fundamental transformations are likely to be very high to the generations that live through them.[159] In today's world, entire nations or economies cannot reasonably be expected to uproot, nor does the life of a human being last long enough in most cases to see long-term regenerative transformations realized in nature. This report's focus on today and the near future means that many of the potential long-term gains, such as new farmland in remote uninhabited pre-Arctic regions, are unlikely to be reaped to their full potential.[160] Likewise, technological solutions yet to be developed should not be counted on to face off or counteract negative impacts in the near future.

Some economic sectors are more dependent on environmental conditions than others. Agricultural productivity is highly dependent on temperature and precipitation.[161] Water supply is dependent on how precipitation patterns and evaporation rates change.[162] The catch potential in fisheries is dependent on water temperatures and the acidity level of oceans, which is rising in large part due to climate change.[163] Researchers have built complex economic models to estimate projections for economic stresses due to climate change in these sectors.[164]

Economic models can also estimate economic impacts on non-market sectors.[165] The stresses described in this chapter include projections for the economic impacts on natural ecosystems, for example. Climate change is projected to have irreversible effects such as the loss of species and the deterioration of complex natural ecosystems.[166]

Climate change is also projected to result in added costs to other sectors. For example, more extreme temperatures will have a significant impact on the costs of energy for heating and cooling.[167] But these costs are usually regarded as adaptation costs rather than direct economic stresses, so they are excluded from the estimates in this chapter.

Agriculture is sensitive to climate change in a variety of ways, not all negative. In mid- to high-latitude regions, particularly in the northern hemisphere, moderate increases in temperature and rainfall changes are expected to lead to a small gain in crop yields and livestock production.[168] Increasing concentrations of CO_2 in the atmosphere may also benefit crop yields, making crops grow faster and more efficiently, although the extent to which this is the case is still debated.[169] Common weeds, for example, are found to benefit most from the CO_2 effect, which is one key factor counteracting its potential benefits.[170]

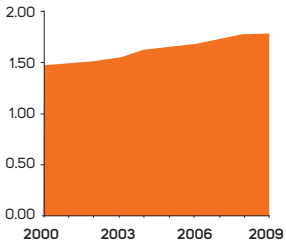
Low-latitude regions are expected to experience negative yield impacts for major cereals such as wheat and rice. The loss of water resources in areas that already experience high levels of water stress and low precipitation can have significant negative effects on agriculture. We expect that these effects will be compounded by the increased frequency of extreme weather events such as drought, flooding, and fires. These impacts are expected to affect vulnerable groups in the poorest countries the most. Smallholder and subsistence farmers are particularly vulnerable. The national statistics presented in this report often do not sufficiently convey the vulnerabilities of these communities.[171]

However, we expect that forestry as a sector will not suffer overall heavy economic losses in the near term. The outputs of forest products are also projected to enjoy some benefits from increased CO_2 concentrations. But forestry will suffer some of the same challenges as agriculture, particularly where water is scarce and where the frequency of extreme weather events increases.[172] Over time, some trees will no longer be suited to a warmer climate, while other trees will become more relevant.

ENTIRE NATIONS OR ECONOMIES CANNOT REASONABLY BE EXPECTED TO UPROOT, NOR DOES THE LIFE OF A HUMAN BEING LAST LONG ENOUGH IN MOST CASES TO SEE LONG-TERM REGENERATIVE TRANSFORMATIONS REALIZED IN NATURE

GLOBAL AGRICULTURAL PRODUCTION

Billions of Dollars (Gross)

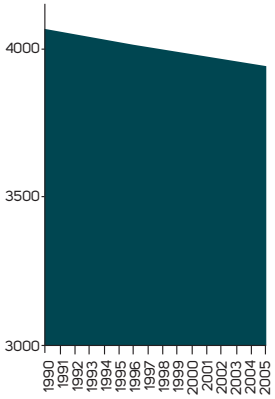


Source: FAO

Agricultural production is expanding around the world, due mainly to increases in living standards in developing countries, particularly in Asia, but also because of continued global population growth. In the short term, the impacts of climate change on agriculture, in particular, food production will be worst on a local level. But in time the global impact on agriculture will worsen around the world.

FORESTS

Hectares (millions)

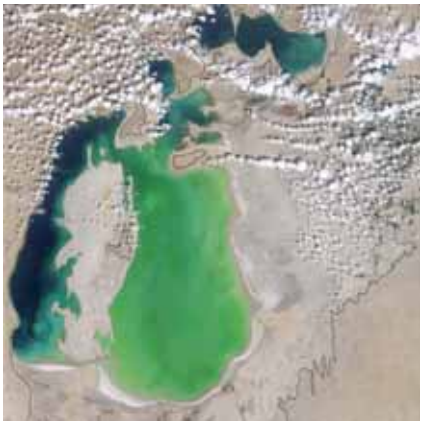


Source: FAO Global Forest Resources Assessment 2005 (FRA 2005)

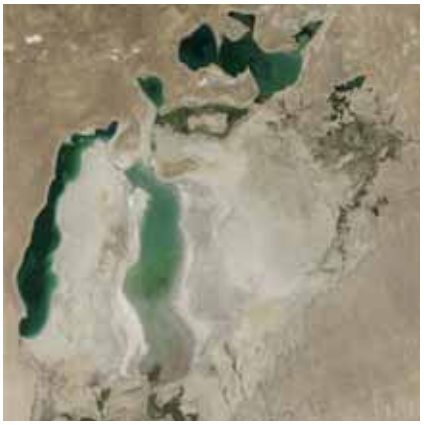
A drop in the land area of forests is mainly due to deforestation to make way for additional agricultural production for food, bio-fuels and other non-forestry purposes. The slash and burn tactics used in many cases to remove forests is also a major contributor to global emissions of greenhouse gases.

Water supply is expected to decrease due to climate change around the world but particularly in regions already affected by water stress such as Central Asia, North Africa, and Sub-Saharan Africa.[173] Widespread glacial melt is causing local surges in water in some cases, but the overall trend is depletion, which already stresses local water supplies in mountainous or mountain-fed countries affected by the phenomenon.[174]

Aral Sea year 1989



Aral Sea year 2000



Aral Sea year 2010

Source: NASA

The Aral Sea is one of the most striking examples of environmental degradation on the planet today. One of the four largest freshwater lakes in the world some 50 years ago, it has now almost completely vanished. Unsustainable exploitation of the Aral Sea's water stocks for commercial purposes is the main cause of its dramatic disappearance. However, some climate models do point to higher temperatures and less rainfall on the east coast of the Caspian Sea in the region of the Aral Sea. Any role of climate change is difficult to disaggregate, but clearly rapidly rising temperatures and lowered rainfall will only exacerbate existing water resource mismanagement. Time will tell if more stringent measures will allow the lake to regenerate with the same speed as it disappeared.

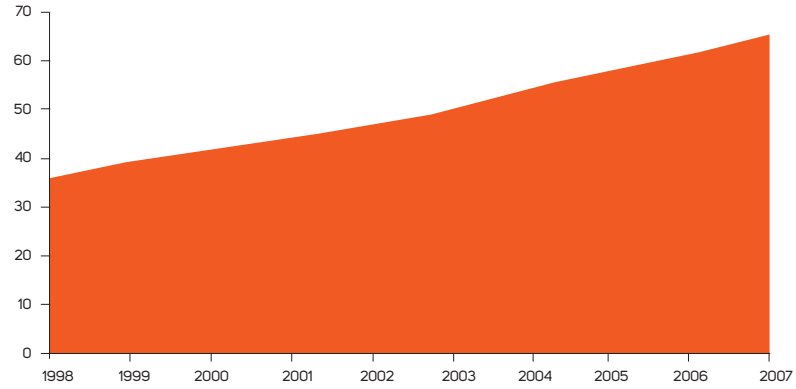
Economic stresses affecting natural ecosystems are expected to have significant costs already today and in the near term.[175] For example, higher temperatures are especially affecting alpine species whose habitats are rapidly disappearing. Boreal forests will completely disappear in some places, to be replaced by more temperate species.[176] Mountainous countries of Asia and South America are particularly impacted, since temperature increases are felt more strongly in alpine climates.[177] Sea-level rise is also damaging coastal wetlands inundated by salt water. Wetlands of this kind are among the most diverse habitats for species of all kinds – birds, insects, fish, and mammals.[178] Their decline is a tragedy for the planet similar in scale to the almost inevitable disappearance of the world's coral reefs.[179] The loss of species is a particularly dramatic effect of this environmental degradation. Indigenous populations that rely on the strength of the biodiversity of their local environment are particularly vulnerable to ecosystem damage of this kind.[180]

The latest studies of the impact of climate change on fisheries point to a dramatic redistribution of the global maximum catch potential between different parts of the world. The tropics are projected to suffer a drop of up to 40% in catch potential by 2055, while high-latitude regions are projected to see a 50% increase in the same period.[181] Overall, though, the expected impact of climate change on fisheries is negative. This dynamic is taking place against a background in which many of the world's fish stocks are facing depletion or are already in decline due to unsustainable fishing practices that continue to increase production and catch but are eating away at the world's fish stocks.[182] Warmer waters favour disease in fish and growth of toxic algae that kill fish and the aquatic life they feed from.[183] Higher temperatures are also fatal to coral, whose bleaching effect is greatly accelerating around the world. But warming northern seas and the disappearance of ice covering the Arctic seas will bring about a large increase in fish stocks in these areas, although not enough to compensate for losses elsewhere. This is particularly bad news for the one sixth of the world's population, mainly living in developing countries close to or within the tropics, that relies on fish as a principal food source.[184] And the impacts on fisheries are not limited to the world's oceans.[185] The second largest body of fresh water on the planet, Lake Tanganyika, an East Africa great lake, has become warmer, increasingly stratified, and less productive over the past 90 years. The problem of

freshwater fish stock depletion over and above unsustainable fishing is comparable to that of stock depletion in the warming oceans. However, there is insufficient scientific basis and data available for the Monitor to take into account the impact of climate change on freshwater fish stocks. This is an area that merits urgent research given that many river delta countries, and communities relying on large lakes like Lake Victoria, derive significant proportions of their agricultural economy and also their diet from freshwater fish.[186]

FISHERIES PRODUCTION

Tons (millions)



Global fishery production has been expanding rapidly but at highly unsustainable rates that are depleting fish stocks around the world.

The impacts of climate change on these primary sectors are likely to result in a significant shift in production from low-latitude to medium- and high-latitude regions.[187] These impacts add increased pressures on the food security of the poorest communities, which will face colossal health impacts of malnutrition, especially in children, as is estimated in the Health Impact chapter in this report.

It is also possible to calculate the share of disease burden attributed to climate change in economic terms as lost productive output due to sickness or death. This report has not included such calculations in its assessment of economic stresses. However, the Report of the Commission on the Macroeconomics of Health calculated, for instance, that in 1999 HIV/AIDS was costing Sub-Saharan Africa between 5.8 and 17.4 percent of GNP potential every year.[188] At the time of estimation, HIV/AIDS was estimated to be responsible for 36 million disability-adjusted life years (DALYs) or years of active life foregone due to injuries/illnesses, including premature death. In 2000, the WHO estimated that climate change was responsible for 5.5 million DALYs. The amount for 2010 would be more than double that given that this report estimates climate-related mortalities are now over 350,000 per year, compared with the 150,000 estimated by the WHO for one decade ago.[189] That figure could potentially more than double once more by 2030, with an economic impairment that is difficult to calculate, but potentially very large.

The prices of basic foodstuffs net of any influence from climate change are already expected to rise by 2050 in real terms by between 39 and 72 percent, depending on the foodstuff, as a result of expected demand shifts, population growth, and competition with biofuels for land.[190] In a situation of such extreme scarcity, the expected decline in agriculture due to climate change could force a tripling of the price of wheat based on estimations by the International Food Policy Research Institute.[191] The 2007-2008 global food crisis led to widespread civil unrest and outbreaks of hunger when a spike in oil prices, drought, and other factors dramatically inflated food prices.[192] If that is any indication of how such outcomes might affect the world's poorest communities, the impact of further surges in food prices could have devastating consequences.

THE EXPECTED DECLINE IN AGRICULTURE DUE TO CLIMATE CHANGE COULD FORCE A TRIPLING OF THE PRICE OF WHEAT

LINKS FROM CLIMATE CHANGE TO IMPACT INDICATORS

CLIMATE CHANGE EFFECTS	PHYSICAL CHANGES	VULNERABILITIES	IMPACT INDICATORS
• Rising surface temperatures • Changes in local rainfall • Increased CO_2 in atmosphere	• Land degradation and desertification • Water pressure • Loss of soil fertility • Landslides and erosion	• Reduced crop yields • Loss of livestock productivity • Loss of income for farmers	Agriculture sector loss/gain • Described as the economic value of impacts on the agriculture sector due to climate
• Rising surface temperatures • Changes in local rainfall and river run-off patterns	• Loss of forest and wetland ecosystems • Loss of soil fertility • Landslides and erosion • Changes in coastal morphology	• Loss of forest and wetland ecosystems • Energy insecurity and deforestation (biomass)	Forestry sector loss/gain • Described as the economic value of impacts on the forestry sector due to climate change
• Rising surface temperatures • Changes in local rainfall and river run-off patterns	• Sediment pollution • Desertification • Salinization of fresh water resources • Melting glaciers • Precipitation and evaporation rates, including flooding and drought	• Decreased accessible water stocks	Water resources loss/gain • Described as the economic value of impacts on water resources
• Loss of biodiversity and ecosystem services	• Gradual environmental degradation	• Accelerated species extinction rates • Species migration • Loss of ecosystem services	Species/ biodiversity loss/gain • Described as the economic value that people are assumed to place on the impact of climate change on ecosystems, biodiversity, species, landscape, etc
• Rising ocean temperatures • More acidic oceans	• Fish habitat changes • Salinization of freshwater aquaculture/fish farms	• Shift in species distribution • Loss of marine and freshwater fish stocks • Increased vulnerability to intense fish stock exploitation • Loss of income for fishery workers	Fisheries sector loss/gain • Described as climate change impact on the value of fisheries sector exports

THE GREAT BARRIER REEF THREATENS TO TURN INTO A GARDEN OF SEAWEED AT JUST ONE MORE DEGREE OF WARMING

The economic stresses, as captured in this report, are by no means exhaustive. They reflect the limitations of the current research on economic impacts, particularly in the developing world.

Tourism is an example of a service sector industry that will be heavily affected by climate change but for which no established method exists to quantify the impact. And so the effect is not included here. Mountain ski resorts

and unique island paradises are nonetheless expected to be worst hit by rising heat and sea-levels. The world's largest coral sea, the Great Barrier Reef, which threatens to turn into a garden of seaweed at just one more degree of warming, could not be replaced as a tourist destination.[193] The effects will be worst in lower-income communities, such as for small island developing states including the Maldives, Mauritius, Seychelles, and dozens of other countries in the Caribbean and the Pacific.

There are other economic sectors dependent on natural conditions that will experience economic stress, but we have not measured those impacts here. Water supply, for example, will impact the agricultural processing industries (such as food processing, brewing, and textiles) and other industries with high water consumption (such as extractive industries and chemicals).[194] And transportation is likely to be increasingly disrupted as a result of extreme weather and the short-term costs linked to a potential shifting of trade routes.[195]

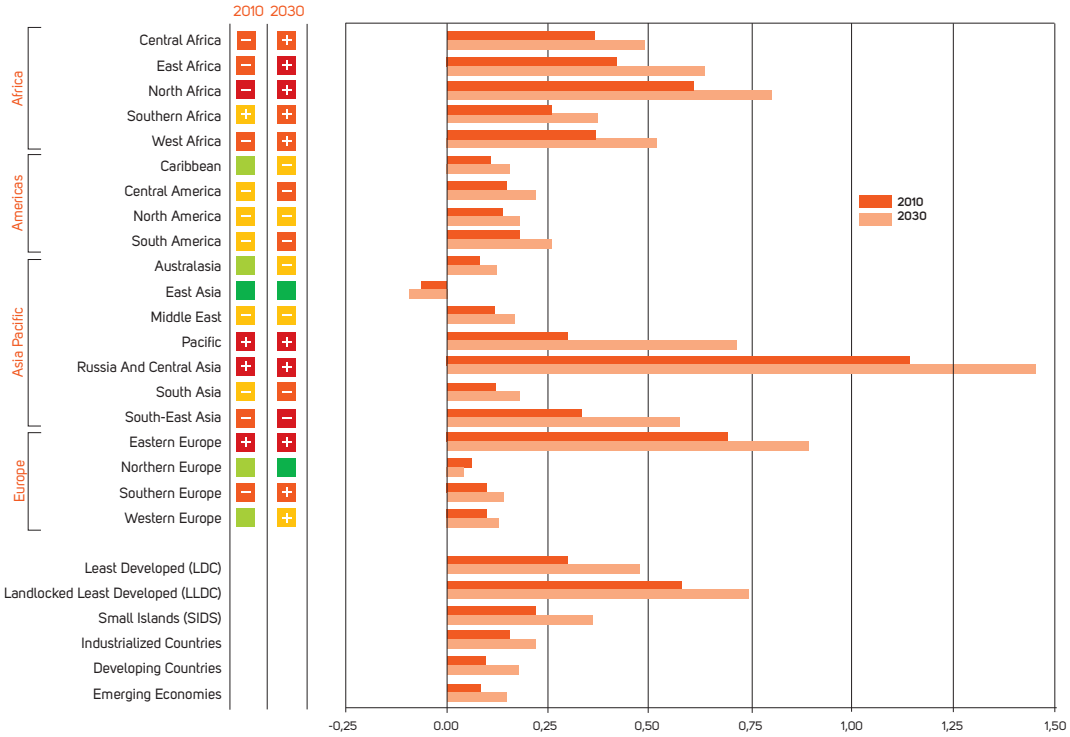
WHO SUFFERS?

The largest economic stress impacts by 2030 due to climate change are projected to be in Central Asia and Russia, and in Eastern Europe, the Pacific, and large parts of Africa. These are significant impacts of sometimes 1% or more of GDP in regions already plagued by the effects of water scarcity and challenging agricultural markets.

However, North Africa, regions of Sub-Saharan African, Pacific island states, and Southeast Asia also bear significant burdens of around 0.5% of GDP. While the absolute losses are much smaller, the human impact of economic stresses is likely to be felt acutely in regions that already suffer high rates of poverty and have very large vulnerable populations. Particularly in the somewhat longer term of 2050 and 2080, it is expected that South Asia and Sub-Saharan Africa will experience significant challenges due to falling crop yields because of rising temperatures.[196]

IMPACTS AROUND THE WORLD

The regional and socio-economic distribution of climate-related economic losses relative to gdp in 2010 and 2030
Additional Economic Losses (percent of GDP)



The countries projected to face the worst impacts of climate change are predominantly Pacific island states, due to negative impacts on fisheries in tropical waters, and Central Asian countries, due to loss of water resources.

The region most resilient to the economic stress impacts of climate change is Northern Europe. Denmark and Norway are the only countries projected to experience an improvement in gains over the period from today to 2030, progressing from Moderate to Low vulnerability. Iceland is also projected to retain Low vulnerability. These regions stand to benefit due to their high latitudes, where an increase in temperature is expected to benefit their fishery outputs, in particular.

East Asia, China, Mongolia, and North Korea are also projected to maintain a Monitor factor of Low due to overall economic stresses. However, these countries are projected to experience significant negative impacts in other areas. The overall positive economic stress impacts in these countries could mask significant negative effects in subregions of these countries.

The largest developed economies in the world, including the US, Japan, and Germany are among the worst affected in absolute terms. But large developing economies such as Russia, Brazil, and India, as well as Egypt in North Africa and Thailand and Indonesia in Southeast Asia also face significant burdens. Overall, the 10 countries bearing the largest burdens will collectively face 75% of economic losses in absolute terms.

THE 10 COUNTRIES BEARING THE LARGEST BURDENS WILL COLLECTIVELY FACE 75% OF ECONOMIC LOSSES

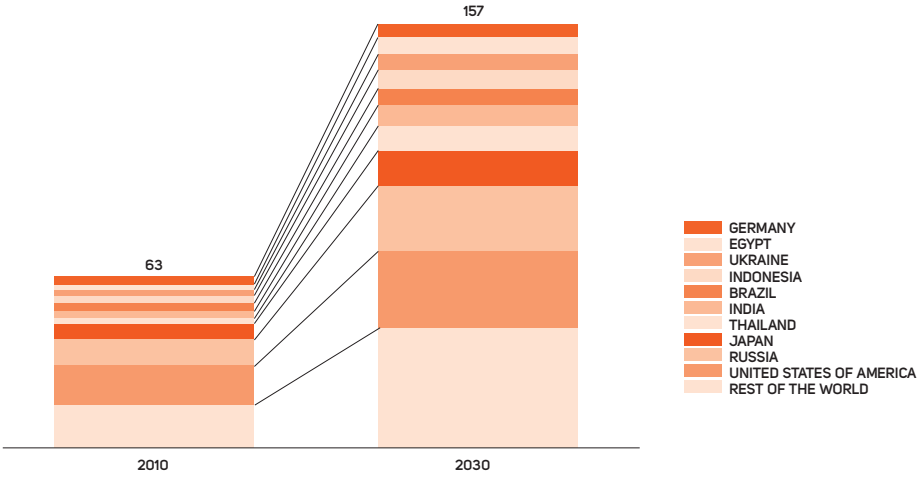
WORST HIT AND LEAST HIT (2030)

The top 10 countries worst and least affected by habitat loss related to climate change in 2030 relative to their size

WORST	LEAST
VANUATU	ICELAND
SEYCHELLES	NORTH KOREA
MARSHALL ISLANDS	MONGOLIA
MALDIVES	CHINA
GEORGIA	NORWAY
KAZAKHSTAN	DENMARK
MOLDOVA	CYPRUS
TAJIKISTAN	SWEDEN
RUSSIA	MALTA
KYRGYZSTAN	SPAIN

HOTSPOTS: ECONOMIC LOSSES

Countries with the largest total climate-related economic losses
Additional Economic Losses (billion USD PPP)



THE IMPACT TOMORROW: 2030

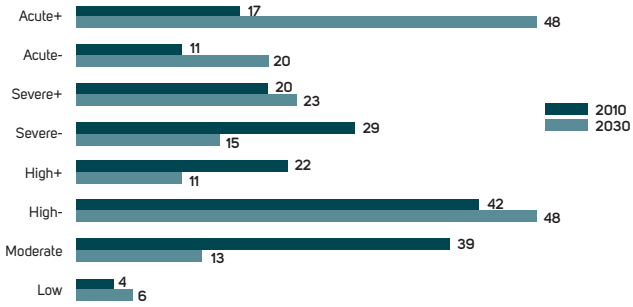
The three regions experiencing the fastest progression in economic stress impacts are the Pacific islands states and Southeast Asia, primarily due to negative impacts on fisheries, and Sub-Saharan African regions, particularly due to negative impacts on water supply.

The number of countries with Acute climate vulnerability factors more than doubles to almost 70 between 2010 and 2030. At the same time, a small number of countries are projected to experience an improvement from Moderate to Low vulnerability.

VULNERABILITY SHIFT

The change in the number of countries by each Vulnerability Factor between 2010 and 2030

Number of Countries by Vulnerability Factor

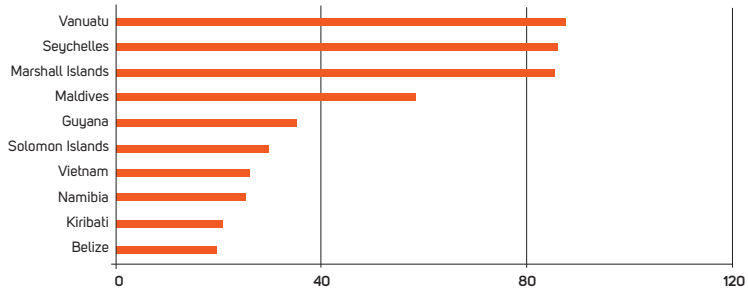


Small island developing states like Maldives, Marshall Islands, Seychelles, and Vanuatu all face fast progressions in economic losses. This is also the case for Vietnam in Southeast Asia and for Namibia in Southern Africa. Negative impacts on fisheries play an important role in the acceleration of negative impacts for these countries between 2010 and 2030.

HIGH SURGE VULNERABILITY

Countries with the fastest growing climate-related economic losses between 2010 and 2030

Percentage increase in climate-related economic losses



SPOTLIGHT: SUPER DROUGHT

Many of the worst types of climate change impacts come from the synergistic interaction between existing degradation or depletion of natural resources and shifts in climate that reinforce these. Depleted water stocks, rainfall changes, heat, drought, and the agricultural and human consequences of these combined effects form danger-prone environment in poorer communities where resource management is insufficient. Northern India, for example, is generally becoming drier due to shifts in the Indian monsoon in areas where water resources are increasingly scarce as a result of non-sustainable pumping of groundwater.[197] The combination of unsustainable resource use and climate stress on the resource could lead to super-droughts with potentially catastrophic human and ecosystem impacts for the region.

India is home to about 16% of the global population but has only 4% of the total water resources, with the irrigation sector consuming 83% of India's. The main water source of water replenishment in India consists of precipitation within Indian territory.[198]

In 2009, the poor monsoon season caused severe drought impacts in 40% of districts. The northwestern and northeastern parts of the country were worst affected amid one of the weakest monsoon seasons for almost 40 years.[199]

Between August 2002 and October 2008, three northwest Indian states lost a volume of water from underground supplies equal to more than twice the capacity of Lake Mead (1 1/4 trillion cubic feet of water), the US's largest reservoir.[200] Evidence points to the pumping of water from wells for irrigation as highly damaging to India's resources. Without measures to curb demand, further climate stresses on dwindling groundwater supplies could cause serious drinking-water shortages and erode crop production in a region inhabited by over 100 million people.[201]

THE ASSESSMENT

The Economic Stress impact area is calculated by using a set of variables indicating the projected economic losses in different sectors as a share of GDP due to climate change. Estimates for four economic sectors are based on the FUND (2.8n) model.[202] The model links exogenous population and per capita income scenarios with simple models of technology, economics, emissions, atmospheric chemistry, climate and sea-levels in order to estimate impacts such as migration, disease burdens and economic effects on a sector basis.

In addition to reliance of FUND, economic losses in fisheries are calculated using Cheung et al. 2010 estimates.[203] Cheung et al. estimate the change in maximum catch potential due to climate change.

FUND offers national level economic loss estimates but many of its parameters are at the level of 16 regions meaning country effects encapsulate the average effect across a sub-region leading to inaccurate assessment results. For instance, Spain (High-/High-) is an example of a country that we expect to be worse impacted than Western Europe -- its model home sub-region, one also incorporating Northern Europe. Spain is affected in relation to water resources, an anticipated increase in temperatures (and plant evapotranspiration) and a decrease in rainfall, by 5%-10% to up to 20%-22% by the end of the 21st century.[204] Northern Europe on the other hand may be set to gain in agricultural production due to climate change.[205]

The Baltic states (Acute+/Acute+) are examples of countries that we expect to be less impacted than countries from the former Soviet Union on average.

The key variable driving the findings on economic stress are water resources. A large part of the water resources impact concerns the agricultural sector, although other key sectors drawing heavily on water are also concerned.

The finding that stands out from the model is that Central Asia, Russia and Eastern Europe face significant water resources impacts.[206] This includes for example Russia (Acute+/Acute+), Kazakhstan (Acute+/Acute+) and Poland (Severe+/Acute-). The key explanation for this is that these regions have continental climates (as opposed to coastal). They are projected to face high temperature rises and their water resources are sensitive to the changes (particularly due to "evapotranspiration").

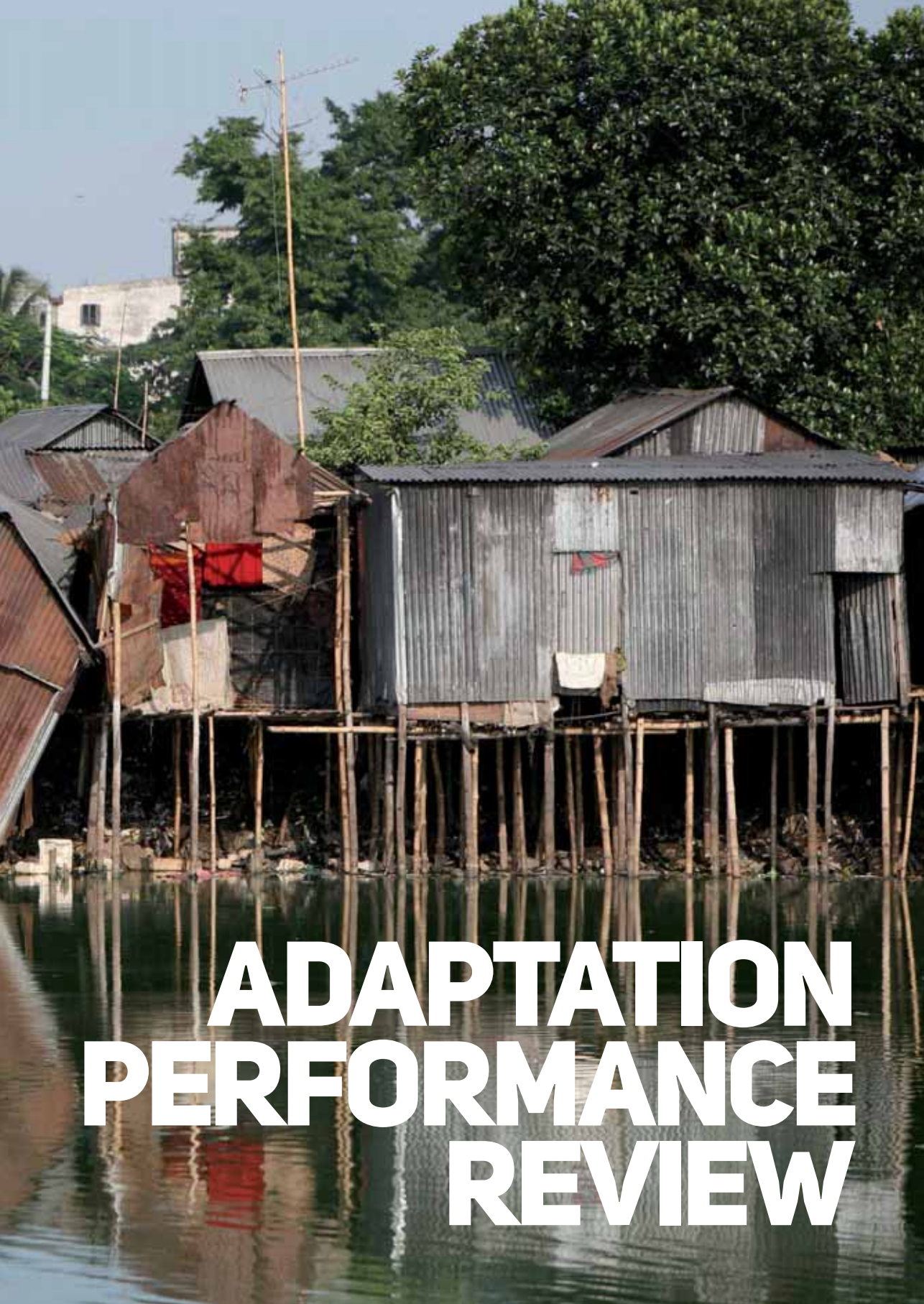
Countries in South Asia on the other hand stand out for relatively low vulnerability, for example Afghanistan (Moderate/High-), India (High-/High-) and Pakistan (High-/High-) regardless of expected continued high temperatures. These countries bear a high health burden among children due to causes related to nutrition and water access. They are also projected to be among the hardest-hit by declining crop yields in the longer term.[207]

The key to understanding why the Economic Stress assesses only a Moderate/High factor to the South Asian countries is that the worst impacts globally in the near term (our 2010/2030) are related to water resources rather than temperature. The majority of South Asia is not expected to suffer significant water stresses as a result of climate change -- although major water stress issues prevail for other reasons. Shifts in precipitation/evaporation/river flows drive the "early" results, while projected temperature impacts on yields follow by 2050/2080, since water impacts have a proportionally higher impact on agricultural yields for instance than higher temperatures. This is why Central Asia/Russia and North Africa experience impacts sooner than South Asia.[208]

A number of Small Island States, such as the Maldives (Severe-/Severe+), the Marshall Islands (Acute-/Acute+) and other Pacific countries are to be found near the top of the list due to fisheries impacts, in particular related to the expected destruction of coral reefs, which are much more moderate for instance for the rest of South Asia.

Division and Wall Street in Colfax, Iowa in August 2010. Waters are receding from record flooding. Source: FEMA/Jace Anderson.

Slum houses in Dhaka, Bangladesh, raised above ground level to protect against flooding. Source: Manoocher Deghati/IRIN.



ADAPTATION PERFORMANCE REVIEW

ADAPTATION PERFORMANCE REVIEW

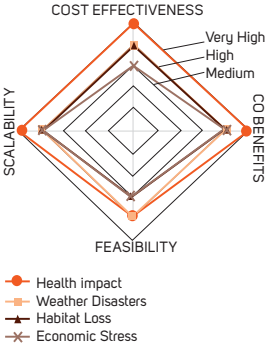
The Adaptation Performance Review assesses over 50 key measures that can be taken to reduce dangers and harm to communities and the planet across the four main impact areas of this report. Highly cost-effective actions exist for minimizing nearly every type of impact assessed in the Climate Vulnerability Monitor. Technically speaking, the human toll of climate change is entirely preventable and should be immediately addressed through reinforced financing to health and disaster-prevention programmes such as those examined in this report. For all other stress areas, efforts will likely have to be substantially stepped up if we are to avoid major, irreversible harm. As climate change intensifies, the costs of adaptation could escalate out of all proportion. So it is also extremely urgent that we take ambitious parallel action to stem greenhouse gas emissions, which are the principal cause of this growing challenge.

FINDINGS

A key conclusion of this Adaptation Review is that, while it is extremely inexpensive and feasible to address some impacts (especially those that are health-related), other impacts (especially those relating to loss of human habitat) are extremely expensive and much more challenging to implement. In some cases, top-down policies will be more cost-effective than bottom-up measures, although a combination of both is desirable. Ultimately, there is no excuse for inaction when a non-exhaustive study such as this is able to identify so many cost-effective options for tackling all of the main types of climate impacts. However, the difficult task of countering rising seas, drying lands, growing deserts, warming oceans, and melting glaciers will require massive investments in protection and conservation efforts.

Adaptation measures that address the health impact of climate change are generally the most cost-effective of the groups of actions reviewed here. Weather disaster responses are, on average, the next most cost-effective group, followed by measures for dealing with economic stresses. Battling the threats of habitat loss entails some of the most expensive actions and some of the least feasible. But even in this impact area, half of the measures reviewed here received either a high or very high rating, meaning cost-effective actions are still readily available even for addressing the most challenging of concerns.

REVIEW FINDINGS



Damage from Hurricane Ike in Bolivar Peninsula, Texas. Source: FEMA/ Jocelyn Augustino.

RESULTS OF ADAPTATION PERFORMANCE REVIEW BY IMPACT AREA				
EFFECTIVENESS RATING RECEIVED	**HEALTH IMPACT**	**WEATHER DISASTERS**	**HABITAT LOSS**	**ECONOMIC STRESS**
	% of all Measures Assessed (rounded)			
VERY HIGH	70	20	10	35
HIGH	30	60	40	25
MEDIUM	-	20	50	40
MOST FREQUENT VALUE	Very High	High	Medium	Medium
MOST FREQUENT EVIDENCE BASE VALUE	High	High	Medium	High

That said, in time it will become extremely difficult for the types of local-level measures examined here to meaningfully hold back global forces, such as the devastating impact of higher sea temperatures on coral, for example. Adaptation will increasingly involve choices about what to preserve, since enormous amounts of resources might otherwise be wasted on the impossible. In addition to the broader challenge of climate change, we may face tough choices of whether to prioritize adaptation, mitigation, or other development planning actions. And the choices we make could reduce the ability of some ecosystems or communities to withstand change. For example, building up small-scale hydro power plants as a way of reducing greenhouse gas emissions could exacerbate competition for already scarce water resources.[209]

ADAPTATION WILL INCREASINGLY INVOLVE CHOICES ABOUT WHAT TO PRESERVE

Where the impacts of climate change are most acute, adaptation will invariably have to be our top priority. But that decision could come at a further loss to economic or human development and might undercut any benefits of adaptation due to the close link between human development and climate vulnerability.

This problem underscores the express need to ensure that low-income communities highly vulnerable to climate change have access to adequate external resources. Compounded pressures could otherwise trigger vicious cycles in which promising options for responding to impacts quickly vanish as communities find themselves struggling to emerge from a crisis alone.

In analyzing possible measures for adapting to climate-related changes, the report was able to depend on a well-documented evidence base of previous experience that was fairly consistent and generally good. This is mainly because the areas of health, disaster reduction, and economic development include many well-established programmes that have been actively pursued by local communities or the health, development aid, disaster reduction or humanitarian relief domains for years, even decades. The impact area with the least robust evidence base reviewed was again habitat loss. Habitat loss impacts, such as widespread desertification, are relatively new compared to the other impacts looked at. It will take some time before responses to habitat loss have built up a readily accessible reference base equal to that of the other areas.

Communities under stress are already undertaking a number of adaptation measures on their own.[210] This so-called "autonomous adaptation" occurs when farmers and communities automatically adjust to climate-related changes and reap potentially beneficial effects. However, since the rate of change is accelerating, large-scale impacts are already outstripping the ability of the many vulnerable communities to persevere.[211] The levels of impacts outlined in the Climate Vulnerability Monitor describe the extent to which communities are already unable to autonomously adapt to the challenges they face today. Adaptation measures would have to be stepped up significantly in communities around the world, especially those with a vulnerability factor of high to acute, if these impacts are to be brought to a minimum.

Most measures taken to counteract negative impacts of climate change are also likely to bring substantial additional benefits for economic growth, socio-economic development, general disaster risk reduction, and the diminution of greenhouse gas emissions.

In particular, many of the measures reviewed here have clear benefits for each of the first 7 Millennium Development Goals (MDGs), which are the most internationally recognized targets in the fight against poverty. Measures relating to water, agriculture, and malnutrition all clearly address the first MDG, which focuses on the eradication of extreme poverty and hunger and is seeing some of the slowest progress of all the goals.[212] Many health measures aimed at climate-sensitive diseases will have wide-ranging beneficial effects across MDGs 3, 4, 5, and 6. Strengthening ecosystems and resource preservation in efforts to counter habitat loss and economic stress, will also help fulfil MDG 7 on sustainable development.

Meanwhile, bringing international resources to bear on the problem, such as programme funding from the highest polluting nations, and further reducing trade barriers to support the most vulnerable communities dealing with climate impacts, would be completely aligned with the spirit of MDG 8 – "Develop a global partnership for development".[213] A programme to disseminate technologies useful for adaptation and emission reductions from highly developed economies to the lowest-income groups would likewise support MDG 8.

Since most of the current impact of climate change affects lower-income or developing countries, many of the programmes assessed in this review are specifically focused on the needs of the most vulnerable groups. But wealthy countries are by no means spared the impacts of climate change, particularly in economic terms, and many of the actions reviewed here are equally pertinent to any given income setting.

THE MILLENNIUM DEVELOPMENT GOALS FOR 2015

GOAL 1	Eradicate extreme poverty and hunger
GOAL 2	Achieve universal primary education
GOAL 3	Promote gender equality and empower women
GOAL 4	Reduce child mortality
GOAL 5	Improve maternal health
GOAL 6	Combat HIV/AIDS, malaria, and other diseases
GOAL 7	Ensure environmental sustainability
GOAL 8	Develop a global partnership for development

"AUTONOMOUS ADAPTATION" OCCURS WHEN FARMERS AND COMMUNITIES AUTOMATICALLY ADJUST TO CLIMATE-RELATED CHANGES

BACKGROUND

The aim of the Adaptation Review is to clarify which actions are known to be both highly effective and readily available to communities seeking to minimize the negative impacts of climate change.

THE METHOD

53 different measures have been reviewed here. These measures were identified through a detailed desk research exercise with the aim of gathering together a broad set of actions and programmes for which there was reasonable information available on cost-effectiveness and other performance indicators. This review includes only those measures for which there were adequate levels of information relating to various aspects of effectiveness, particularly cost-effectiveness. This

information mainly stems from development or specialist literature or National Adaptation Programmes for Actions (NAPAs) and varies in quality from one impact area or measure to another. In some cases, the unsatisfactory levels of information on specific types of actions revealed a major gap in our toolset for measuring the success of adaptation measures and policy-making – a gap that must be addressed if we are to improve our understanding of the climate challenge.

The actions included here are those that relate to the impact areas covered in the Monitor, so they are not comprehensive. Also, certain climate-related impacts, such as permafrost thawing, for example, are not taken into account either here or in the Monitor.

Neither are the actions highlighted here necessarily what would be considered "adaptation policies", since they have only been framed in relation to Monitor impacts and consist of just individual projects in most cases. This catalogue clearly represents just a subset of all possible effective adaptation responses, but it still provides a good indication of the different types of options available.

All measures are rated in terms of their relative effectiveness in reducing a given impact as identified in the Monitor. So, for example, a measure may be rated as beneficial in reducing mortality rates resulting from diarrhea, or in countering lost income due to low agricultural yields in water stressed areas. Beyond cost-effectiveness ("Cost-Effectiveness"), each action has also been reviewed for its co-benefits in supporting other positive changes in society and its ability to equitably benefit wide-ranging groups of people, especially the poor ("Co-Benefits"); for its ability to be easily implemented, bearing in mind uncontrollable risks ("Feasibility"); and for its ability to be easily reproduced in different places ("Scalability"). The assessment methodology we used is explained in more detail in the end matter of this report.

The various action sheets that follow in this section of the report detail each of the measures reviewed. They include information about the effect ("Immediate", "Short-Term", and "Long-Term") that an action will have in terms of reducing impacts. They also detail whether the measure can be rolled out quickly ("Quick Start") or, if not, how long it might take ("Implementation Lapse"). If measures are tied to a programme cycle, such as a school year, the typical timeframe length is also given. Finally, where measures clearly contribute to one or more of the Millennium Development Goals, the specific goal number is a listed under "MDG Boost".

LIMITATIONS AND STRENGTHS

The Review does have clear limitations. For example, most health measures – and several other types of measures – will be significantly cheaper to implement in poorer countries than in highly developed economies. Actions might vary significantly in implementation from one country to another depending on a country's particular situation. For this reason, some implementations could see risks or scalability issues beyond what we have been able to capture in the Review. It is difficult also to compare measures that save human lives to measures that reduce an economic impact within an industry. Nevertheless, each measure does give a fair indication of cost in relation to other types of measures within its own impact area. And The Review makes clear the cost differences between an infrastructure-type response and, say, the promotion of breastfeeding programmes. So interesting insights nevertheless emerge and provide a good indication of the varying options and cost burdens that could apply to a given country depending on its vulnerability profile. Countries should find health impacts, for instance, cheaper in general to combat than desertification or sea-level rise impacts.

Since the Review was organized specifically to verify effectiveness in reducing negative impacts, it has not focused on a number of common adaptation concepts, such as prevention (or the avoidance of harm), adaptive capacity (the ability to deal with change) in the face of long-term climate stresses, or resilience (the ability to recover from a shock) in the face of extreme weather, drought, or other disasters. Nevertheless, the actions assessed here invariably reinforce both adaptive capacity and resilience, such as through coral conservation and re-growth, mangrove planting, or hurricane-resistant housing. They may also help to prevent harm from occurring in the first place through effective flood control, for example.

The Review does, however, have an in-built bias towards concrete practical measures, project-based responses, and infrastructure programmes, since the costs, and sometimes benefits, of such measures are quite clear. Such measures have also largely been the focus of international spending on adaptation and related areas until now.[214]

The Review only takes limited account of external factors that will play a considerable role in the implementation of the actions assessed here, such as underlying governance, legislation, local capacities, policy frameworks, and other factors that will have a critical effect on a country's ability to take adaptation measures. Nor does the Review take into

account financial instruments, such as highly effective private sector strategies of risk transfer through insurance. These are the subjects of numerous other excellent publications of late.[215]

LINKS TO BROADER STRATEGIES

Broader development strategies and policy and legislation responses not captured here also play a critical role in any effective response to the impacts of climate change. For example, the Review only hints at how sustainable governance and management of natural resources such as water, forests, and fisheries are necessary to marine conservation or reforestation programmes.

Diminishing water stocks due, in many cases, to over-extraction or unsustainable usage are just one example of a major natural resource suffering accelerated depletion in areas receiving less rainfall or experiencing more drought as a result of climate change. The impact of climate change on water is also one of the main drivers of economic losses in the Monitor. Rationing or conserving water at the individual or community level such as through rainwater harvesting or micro-irrigation measures mentioned in this Review are examples of how water resources can be better conserved at a grassroots level.

However, bottom-up measures will likely be inadequate if pursued in isolation from top-down policies and efforts. Government intervention through legislation or other policies may be necessary to restrict or manage ongoing extraction or access to water resources in order to avoid total depletion. Ideally, such legislation would in turn encourage wider adoption of the types of water conservation or rationing practices in the Review, which could well become widespread as a result.

REINFORCING PUBLIC SERVICES IS CRITICAL TO A SUCCESSFUL RESPONSE TO THE IMPACTS OF CLIMATE CHANGE

Just as many of the actions in the Review reinforce the MDGs, so too broader human development strategies can play a pivotal role in supporting responses to climate change. Gender development strategies, for instance, have been shown to have a major positive effect on child health – and children are a demographic group heavily impacted by climate change.[216] The creation and maintenance of social safety nets and other non-monetized services that strengthen communities can also reduce vulnerability to climate change.[217]

Many of these types of broader responses rely on adequate governance or robust public services and depend on strong legal systems and institutions capable of implementing and enforcing laws that protect or encourage positive social or individual behavioural changes. In fact, many of the cost-effective actions covered in this Review cannot be implemented in situations with inadequate public services or legal and governance structures. Reinforcing these public services is therefore also critical to a successful response to the impacts of climate change. This also partly explains why so many fragile states are among the most acutely vulnerable to climate change. And for these reasons, communities with both high factors of vulnerability and low human development should be singled out for specific attention.

Salesmen in Congo wade through water at a market in Brazzaville, November 2006. Source: Laudes Martial Mbon/IRIN.

HEALTH IMPACT

There are a variety of measures that can be taken to prevent deaths due to climate change, and many of them are very affordable.[218] Since outbreaks of disease related to climate change are concentrated within certain regions, age groups, and socio-economic groups, good targeting of these diseases is feasible. Life-saving measures to address these health problems are some of the most well-documented and effective measures we have in fighting the negative effects of climate change. Such measures will require financing but could save hundreds of thousands of lives, especially among children and infants.

VERY HIGH
Overall Effectiveness Rating

10 #Actions Assessed

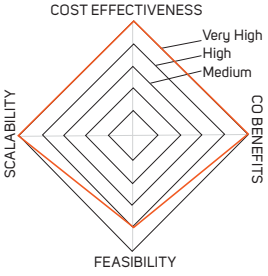
FINDINGS

Around three quarters of the health impacts of climate change involve just three disorders – malnutrition, diarrhea and malaria – and are concentrated in children living in Sub-Saharan African regions and in South Asia.

Only a small fraction of occurrences of these three disorders worldwide are related to climate change. On the one hand, resources of the health, development and humanitarian communities have for decades been put to use to develop highly effective responses to these diseases.[219] Indeed, much of this section of the report is based on the expansive Disease Control Priorities in Developing Countries project, which in its second global edition has brought together large volumes of research from hundreds of experts and organizations active around the world.[220] On the other hand, measures addressing those same diseases – such as the simple mixture of sugar, salt, and clean water used to rehydrate people suffering from diarrhea – are so cost-effective that these diseases almost never lead to death in wealthy countries.

It is the poor that fall victim to deadly but preventable diseases. Whatever measures and programmes are employed to tackle these health problems must support the poorest of the poor, and external resources must support that effort.[221] Indeed, expanded efforts to deal with these diseases in recent years have reduced their frequency.[222] The loss of millions of lives every single year is linked to an ongoing shortfall of support. Climate change is projected to further encumber efforts to tackle these major illnesses. So it is all the more crucial that we step up campaigns to address maternal and child health, particularly in the areas of malnutrition, diarrhea and malaria. Such campaigns are critical to preventing reversals, for example, reoccurrences of malaria outbreaks in areas where the international community has already committed to achieving eradication. Yet health interventions are currently quite underrepresented in national climate-change adaptation action plans.[223]

REVIEW FINDINGS



THE REVIEW

All the health measures assessed in this report registered high levels of effectiveness in limiting the negative effects of climate on health.

For each health concern there is a corresponding array of immediate, medium- and long-term measures that are effective for various age groups and for various urban and rural settings.

All of the health-related interventions included in this report are cost-effective, and several are highly cost-effective, requiring less than USD 500 to prevent one year's ill health (which the health community refers to as Disability Adjusted Life Years).

In almost every case, the measures that could be taken to reduce health problems also have clear socio-economic benefits or other advantages. For instance, in-school feeding programmes also yield educational advantages, and improved water and sanitation facilities help foster wider economic activities.[224]

There is generally a highly comprehensive body of accumulated evidence and empirical and case-study research available to rate the effectiveness of various health measures and to support decisions on how to go about implementing those measures. Guidelines and training programmes are also readily available for all measures suitable to the worst-affected populations, which include lowest-income and conflict-stricken communities as well as communities experiencing emergency situations. In cases where rising temperatures are enabling diseases like malaria and dengue fever to spread to populations in higher altitudes, for instance, existing measures (such as the distribution of insecticide-treated bed nets) can be implemented in the newly effected zones.

The factor most likely to hinder implementation of specific measures to combat climate-change related health problems is feasibility. Improving water supplies is possible, for example, only if a reliable source of water is available. And a range of factors – among them climate change itself – make finding reliable water sources increasingly difficult.[225] Similarly, construction and maintenance of adequate sanitation facilities in rural or island communities require local expertise and resources that are not always on hand.[226]

TIMEFRAME CONCERNS

A phased approach is critical to effectively addressing the health impacts of climate change, and rolling back the burden of climate-sensitive diseases in general, as is the international community's established goal.

A number of measures can have an almost immediate effect and, in some instances, can reliably avert death in the large majority of cases. Bed nets and in-door insecticide spraying, for example, offer immediate protection for families located in malaria-endemic areas by keeping disease-carrying mosquitoes away.[227] Oral rehydration therapies, such as use of water-based sugar-salt solutions, can prevent death and help patients recover from dehydration.[228] None of these interventions permanently reverses the course of disease.

Some illnesses can be tackled at the root of their cause. For instance, Rotavirus A, which causes 90% of infectious diarrhea cases, is passed from person to person via contaminated faecal particles introduced into the body via the mouth.[229] Improved water and sanitation facilities limit transmission of the disease. Immunization can also help prevent the virus from making children sick.

Almost all health measures included in this report fall into the immediate or short-term (impact within one year) categories. Excessive heat notification and response systems, for example, will really only have an effect when a heat wave occurs.[230]

IN ALMOST EVERY CASE, THE MEASURES THAT COULD BE TAKEN TO REDUCE HEALTH PROBLEMS ALSO HAVE CLEAR SOCIO-ECONOMIC BENEFITS OR OTHER ADVANTAGES

HEALTH IMPACT **ADAPTATION ACTIONS**

	ACTION SET	VULNERABILITIES	MOST VULNERABLE POPULATIONS	EFFECTIVENESS RATING	EVIDENCE RATING
1	CHILD SURVIVAL PROGRAMME WITH NUTRITION COMPONENT	• Malnutrition		Very High	Medium
2	SCHOOL HEALTH AND NUTRITION PROGRAMMES	• Malnutrition		Very High	High
3	BREASTFEEDING PROMOTION	• Diarrhea • Malnutrition		High	High
4	ORAL REHYDRATION THERAPY AND ZINC SUPPLEMENTATION	• Diarrhea		Very High	High
5	IMMUNIZATION PROGRAMMES (ROTAVIRUS, HIB, HEPATITIS B, PNEUMOCOCCAL)	• Diarrhea • Acute respiratory infections		High	High
6	IMPROVED WATER SUPPLY INFRASTRUCTURE	• Diarrhea		Very High	Medium
7	BASIC SANITATION FACILITIES	• Diarrhea • Waterborne diseases		Very High	High
8	INSECTICIDE-TREATED BED NETS	• Malaria • Dengue, other vector-borne diseases		Very High	High
9	INDOOR RESIDUAL SPRAYING	• Malaria		Very High	High
10	EXCESSIVE HEAT EVENT NOTIFICATION AND RESPONSE PROGRAMMES	• Cardiovascular and respiratory diseases		High	High

Infants Children Adolescents Adults Elderly Population in poor health

Very low Low Medium High Very high

CHILD SURVIVAL PROGRAMME WITH NUTRITION COMPONENT

1

Community-based nutrition programmes to prevent stunted growth, control disease, and improve survival. Such programmes promote breastfeeding, provide education, and offer counselling on how best to feed children, prevent diarrheal disease, and monitor growth.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	Very High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 1 year

Expense: $2 (less intensive) - $10 (more intensive) per child

Impacts Addressed: **Child health, malnutrition**

Child survival programmes rate highly on scalability, cost-effectiveness, and co-benefits. At $42 per DALY, this programme is among the least expensive of all health programmes assessed here. Improving child health can result in a number of other positive socio-economic benefits. Excellent guidelines and simple, effective training are readily available to help expand this programme to new areas. The programme is also particularly suited to low-income communities vulnerable to malnutrition, since that is a problem it specifically targets.

The programme received a low rating for feasibility, mainly because, in some cases, children take the nutrition supplements and food home to adults rather than consume them themselves. The programme has only a moderate base of evidence for its effectiveness. Additional research and peer-reviewed studies would help more accurately establish the programme's value.

The programme has very quick effects. In highly vulnerable communities, we see the effect well within one year of implementation. That effect continues for the length of the programme cycle, typically one year of duration, and can have benefits beyond that due to its educational component.

MDG BOOST ↑1, ↑4, ↑5

Sources: DCPP

SCHOOL HEALTH AND NUTRITION PROGRAMMES

2

Simple school-based programmes to improve health through low-cost interventions such as treatment for intestinal worms and schistosomiasis; prompt recognition and treatment of malaria; distribution of insecticide-treated bed nets, micronutrient supplements, meals, snacks, and first-aid kits; and referrals of children to youth-friendly clinics and associated programmes.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	Very High	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✗	Programme Cycle	Typically 1 year

Expense: $37 per DALY

Impacts Addressed: **Child health, malnutrition**

School health and nutrition programmes rate highly on cost-effectiveness ($37 per DALY), co-benefits, feasibility, and scalability. This programme is among the least expensive of all health measures assessed here. Improving child health can also lead to better educational results. Such programmes can roll out quickly using existing educational networks and have an especially high impact on the poorest and most undernourished children.

Evidence shows that the number of children reaching school age (defined as 5 to 14 years of age) is increasing due to such child survival programs. In The Gambia, girls were more than twice as likely to enroll in primary school if they had received malaria prophylaxis in early childhood. In Kenya, treatment of Helminth infections reduced absenteeism by one-fourth, with the youngest children (who typically suffer the most ill health) showing the largest gains.

The evidence base for the programme is high -- we have several well-documented examples from various geographical regions. However, not all types of intervention are relevant to all situations or locations, so it is essential to assess the needs of a community prior to each implementation.

The programme's positive impact is consistent only as long as the children continue to attend school. Positive impacts can have an almost immediate effect, since the programme rolls out through existing networks. The programme's effectiveness ends as soon as the programme does.

MDG BOOST ↑1, ↑3, ↑4, ↑5, ↑6

Sources: DCPP

BREASTFEEDING PROMOTION

3

Encouraging new mothers to breastfeed their infants for the first six months of life. Breastfed infants should receive no other food or drink, including water, except for supplements of vitamins and minerals and necessary medicines.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✗	Programme Cycle	Typically 1-2 years

Expense: $0.46-$17.50 per child

Impacts Addressed: **Diarrheal disease**

Breastfeeding-promotion programmes rate highly on scalability, co-benefits, and cost-effectiveness ($930 per DALY). Technical specifications and guidelines for implementing this programme already exist, and global training programmes are well developed and accessible. Promoting increased breastfeeding can result in other health benefits. Exclusive breastfeeding eliminates the intake of potentially contaminated food and water. Breastfeeding also significantly lowers the risk of transmitting infections to children and reduces child mortality rates, especially among the poorest groups. Breastfeeding promotion is among the least costly actions available to the health community today.

The programme has a large base of evidence for its effectiveness. Various empirical studies and economic analyses have been carried out in multiple countries. Studies have shown that in developing countries, breastfed children under six months of age are 6.1 times less likely to die of diarrhea than infants who are not breastfed.

The programme ranks low on feasibility because it relies heavily on behavioural change. For example, it is possible to promote breastfeeding through community-based mothers' support groups, but few such support groups exist, and where they do, their members tend to be women who are already motivated to breastfeed. There is also some danger in promoting exclusive breastfeeding in HIV-affected communities, since there is some risk of transmitting infection to the infant.

MDG BOOST ↑1, ↑4, ↑5

Sources: DCPP

ORAL REHYDRATION THERAPY AND ZINC SUPPLEMENTATION

4

A simple water, sugar, and salt (or similar) solution and a zinc nutrient supplement provided as a drink to patients to prevent dehydration and chronic diarrhea.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Medium				
FEASIBILITY	Very High	Short-Term	✗	Implementation Lapse	✗
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✗	Programme Cycle	Typically 1 year

Expense: $0.02-$11.00 per person

Impacts Addressed: **Diarrheal disease**

Oral rehydration programmes rate highly in feasibility, scalability, and cost-effectiveness. The programme received a high rating for cost-effectiveness, since it is instantly implementable and requires little management, although the cost per treatment can vary widely (from $73- $1,062 per DALY) depending on how the solution is prepared and administered.

The programme has a high feasibility rating due to its high success rate across a variety of contexts, its ease of implementation, and its consistent results. The programme has a high base of evidence for its effectiveness. It is a widely applied tool that has been broadly used for many decades. Its success has been well documented through various studies from WHO and The Disease Control Priorities Project. Also, since rehydration solutions are simple, readily available, and universally applicable, the programme can scale up very easily.

The programme rates low on co-benefits, mostly because its core focus is to avert death due to dehydration, the main cause of fatality in cases of diarrhea.

The programme can be put into operation instantly to avert almost imminent death. However, it does nothing to reduce the problem of infectious diarrhea.

MDG BOOST ↑1, ↑4

Sources: DCPP, Jamison et al. (2006)

IMMUNIZATION PROGRAMMES

5

Rotavirus vaccination to prevent the most common cause of infectious diarrhea, and/or Haemophilus influenzae type B (Hib) vaccination to prevent pneumonia and meningitis.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✓	Quick Start	✓
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 1-3 years

Expense: $17 on average per fully immunized child

Impacts Addressed: **Diarrhea (rotavirus), acute respiratory infections (pneumonia)**

Immunization programmes (including Hib and Hepatitis B) rate highly on cost-effectiveness ($296-$2,478 per DALY) and scalability. In Chile, the government determined that the creation of a combined diphtheria-tetanus-pertussis and Hib vaccine was worthwhile and that the vaccine could be delivered as part of an already well-functioning system of routine immunization.

WHO has already established a standard immunization schedule, and a number of countries operate large-scale, sustainable training programmes at the community level. However, affordable medical care is generally lacking, and inadequate clinical conditions may result in less effective vaccine treatments. Additionally, rural populations may be excluded from treatment due to the difficulties of distributing vaccines to remote areas.

While the evidence base is high, additional research and peer-reviewed studies would help more accurately establish the effectiveness of vaccination programmes. The long-term consequences and co-benefits of vaccinating against diarrheal diseases remain poorly studied. Additionally, investments in R&D are required before large-scale rollout of a rotavirus vaccine programme can be considered.

Immunization has a close to immediate effect protecting against infection and transmission but cannot eliminate an existing infection or fatality risk.

MDG BOOST ↑4, ↑6

Sources: DCPP

IMPROVED WATER SUPPLY INFRASTRUCTURE

6

Installation of hand water pump, standpost, or house connection in areas where clean water supply is limited and no plumbing infrastructure exists.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 1-3 years

Expense: $17 (borehole) - $144 (house connection) per person

Impacts Addressed: **Drinking water, diarrheal disease**

Improved water supply infrastructure programmes rate particularly highly on co-benefits and cost-effectiveness ($159 per DALY). Dozens of viruses, bacteria, protozoa, and helminths cause diarrheal and other diseases. They are generally picked up through fecal-oral transmission, often by drinking contaminated water or eating unwashed foods in areas lacking a clean water supply.

The programme's costs are consistently low, although they may differ in urban and rural environments. The programme improves living conditions and prevents a wide range of contaminants from entering the body. It also has various indirect effects, including time saving (an Indian national survey for UNICEF found that women spent an average of 2.2 hours per day collecting water) and nutritional benefits (if poor households spend less money on water, they will have more funds for food).

The programme rates lowest on feasibility, since it demands ongoing investment and cannot succeed in areas where water is in very short supply. However, the programme has shown that, once implemented, it delivers consistent results. Technical specifications and guidelines are extensively available and fully tested, and many good case examples exist of the programme's success in low-income communities.

Installation is quick, and its effect on halting the spread of disease and bacteria due to unclean water and food is virtually immediate. If the infrastructure is maintained, the programme yields long-term benefits.

MDG BOOST ↑2, ↑3, ↑4, ↑6

Sources: DCPP, Jamison et al. (2006)

Very low | Low | Medium | High | Very high

BASIC SANITATION FACILITIES

7

Construction and promotion of basic sanitation where sanitation facilities are limited.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically after 0-2 months
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $60-$160 per person

Impacts Addressed: **Diarrheal disease**

Basic sanitation facilities programmes rate highly on cost-effectiveness, co-benefits, and scalability. At a construction cost of $60 per capita for basic sanitation facilities and a lifetime of 5+ years for a latrine, this programme remains among the least expensive of the health measures assessed here. Lower-cost models are possible in areas that lack infrastructure or where more complex sanitation systems are not feasible, making such a programme highly cost-effective even where construction costs are high.

The programme is beneficial to all groups in a community lacking sanitation and reduces the spread of diarrhea while also producing socio-economic and cultural benefits. However, it is unclear whether we can attribute the positive effects to the installation of latrines alone, since benefits have only been measured in combination with improved hand-washing habits. Benefits are highest where a clean water supply is also available.

WHO, UNICEF, and the World Bank have already developed technical specifications and guidelines for low-cost sanitation projects, and many well-documented case examples exist. However, there is a lack of training in appropriate construction techniques.

Successful implementation also depends on behavioural changes. Some studies indicate that, to reap the full impact of the programme, communities must make cultural adjustments over time.

Implementation can occur quickly depending on the solution chosen. Benefits accrue immediately thereafter and, with well-maintained infrastructure, last long-term.

MDG BOOST ↑4, ↑6, ↑7

Sources: DCPP, Jamison et al. (2006)

INSECTICIDE-TREATED BED NETS

8

Treatment of purchased or subsidized bed nets with insecticides.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $5 per bed net

Impacts Addressed: **Malaria**

Bed nets rate very highly on cost-effectiveness ($5-17 per DALY) and co-benefits. Use of insecticide-treated bed nets provides personal protection by killing or repelling mosquitoes and is a very effective strategy for controlling malaria. This action is among the least expensive of all known health measures. Bed nets are easy to distribute through subsidies or other programmes, and costs are consistent in Sub-Saharan Africa (the area where malaria is most prevalent). The programme is applicable and relevant to all groups in a community.

Recent cross-country comparisons of economic growth indicate that eliminating malaria can have a strong positive impact on economic development. Currently, bed nets must be treated semi-annually; however, new technology should eliminate this requirement. When bed net users receive basic training in how to use the net, the programme's success rate is high. Protection is only during sleeping hours, but that is a high-risk period, which is why over 20 studies in Africa and Asia have demonstrated a protective success rate of over 50 percent for individual net users.

Training programmes should be culturally sensitive and adapted to local customs. More operational experience is necessary before it is possible to inform national initiatives on how to scale up use. Bed nets function immediately, can be distributed extremely quickly, and the latest models have a lasting effect for many years if well maintained (in particular through the repair of holes).

MDG BOOST ↑4, ↑5, ↑6

Sources: DCPP, Jamison et al. (2006), WHO (2006)

INDOOR RESIDUAL SPRAYING

9

Applying long-lasting insecticides to the walls and surfaces of dwellings.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✗	Programme Cycle	Typically 0.5 year

Expense: $9-$24 per treatment

Impacts Addressed: **Malaria**

Indoor residual spraying programmes rate highly in co-benefits, scalability, and cost-effectiveness ($32 per DALY). Recent cross-country comparisons of economic growth indicate that eliminating malaria – which residual spraying directly addresses – has a strong positive impact on economic development. A 10 percent reduction in malaria has been associated with 0.3 percent higher economic growth per year.

Technical specifications, guidelines, and several training programmes on applying the insecticides are already available, including Roll Back Malaria and WHO implementation programmes.

Indoor insecticide spraying has a consistent impact where it can be applied, although frequent applications are necessary.

Effectiveness will depend on the length of the malaria-transmission seasons and on the insecticide used. The programme has been evaluated by several WHO studies in Africa, the Americas, Asia, and Europe and by empirically based, well-documented assessments. The cost to implement such a programme may be out of reach for many low-income countries, and successful implementation can require extensive planning, coordination, infrastructure, and skills and high coverage levels. Communities may also develop environmental problems due to the toxicity of the insecticide.

The effect of a spraying programme is instantaneous, but most insecticides are effective for just 2-6 months, requiring constant reapplication.

MDG BOOST ↑4, ↑5, ↑6

Sources: DCPP, WHO (2006), Jamison et al. (2006)

EXCESSIVE HEAT EVENT NOTIFICATION AND RESPONSE

10

Programmes combining meteorological forecasts and other data to trigger public health interventions to reduce heat-wave illnesses and deaths.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✓	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically after 6 months
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 2-5 years

Expense: $200,000

Impacts Addressed: **Cardiovascular and respiratory diseases**

Excessive heat event notification and response programmes rate highest on co-benefits. The programme can be cost-effective and easily implemented where advanced public health and meteorological systems are in place, which is the case for many of the worst affected areas, such as Europe and North America.

The programme demands reliable meteorological data and established communication channels that may not always be available or adequate in low-income settings, particularly in remote communities. It is also difficult to guarantee that communications will reach the appropriate groups/persons. While clear technical specifications and guidelines exist, the programme has lower relevance for low-income countries, since heat waves cause most damage in regions where extremely hot weather is relatively infrequent. Local coping methods are already common in areas that regularly experience high heat, such as many low-income countries in Africa and Asia.

Several peer-reviewed studies exist on the subject. However, there is no standard way to estimate the impact in different countries. It can take weeks to more than a year to implement such a system. Once established, such programmes are easily maintained into the long-term, provided supportive public and other services are also functioning.

MDG BOOST ↑4, ↑5

Sources: Kovats & Ebi (2006), U.S. Environmental Protection Agency (2006), Ebi et al. (2004)

Bush fire close to the Italian city of Genoa in September 2009. Source: Wikimedia Commons/Janurah.

WEATHER DISASTERS

Weather disasters can occur anywhere a major storm, flood, or wildfire has hit in living memory. Extreme heat, wind, rain, and flooding are cutting new paths of impact.[231] But not everyone is at risk – far from it. Exposure to major floods, storms, and fires tends to be localized and specific. The worst disasters can cost nearly a decade's worth of global loss of life and damage and can wipe out close to half of an economy.[232] Measures taken in advance to help minimize these impacts are not always cheap. Emergency response measures carried out after the fact are usually far more expensive and will never restore the lives lost that could have been prevented with advance action.[233]

HIGH
Overall Effectiveness Rating

11 #Actions Assessed

FINDINGS

Countries vulnerable to more intense weather and fires are an eclectic group. Island paradises such as Belize join ranks with failed states such as Somalia. Coastal nations such as Cuba, Micronesia, Yemen and the Philippines experience similar scales of impacts as landlocked Mongolia or mountainous Bhutan and Boliva.[234]

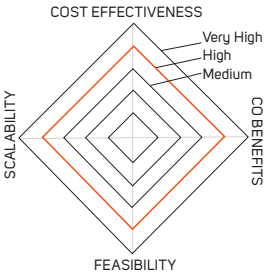
In many cases, even for the most exposed countries, disasters are far from common. For the majority of countries, major disasters occur more on the order of once a decade.

While a disaster, by definition, takes the affected community by surprise, few floods, fires, or cyclones occur in places that have been hitherto untouched by natural disasters, despite the fact that extreme weather is spreading beyond its traditional paths. Unusually strong and unexpected floods or storms can run against prior experience, such as Cyclone Nargis, which devastated Myanmar in May 2008.

Some communities accept risks more or less consciously. The United States' 1938 New England hurricane wiped out tens of thousands of homes and maimed hundreds with its powerful storm surge on Long Island in New York.[235] Today, the affluent West and South Hampton beaches of the area are lined with new homes and buildings, seemingly oblivious to the power of nature.[236]

What overwhelms communities is the breaching of a new threshold. The New Orleans levees breached by Hurricane Katrina,

REVIEW FINDINGS



THE INTERNATIONAL DONOR COMMUNITY IS MORE INCLINED TO PROVIDE FINANCIAL SUPPORT TO A COMMUNITY IN THE WAKE OF A DISASTER RATHER THAN TO PREVENT AS DISASTER FROM OCCURRING IN THE FIRST PLACE

for example, would have been made more robust if they had been expected to withstand more extreme weather than the region had experienced in the past. Since the parameters for climate-caused disasters are shifting, we must regularly challenge the false security of proven, or previously sound, adaptation.[237]

While some communities accept such risks, others simply lack the means to take measures to improve safety. An unfunded USD 2 million emergency flood warning system in Laos, for example, that would be capable of protecting many families from mass inundations, ranks number 7 in the nation's list of climate-change adaptation priorities. Floods of that sort could occur tomorrow or in 10 or 30 years time. In the case of Laos, floods leave nearly half a million people in need of emergency assistance every few years.[238]

The worst natural disasters in modern history occurred when the giant rivers of China, without warning, swamped the plains along the Yangtze or Yellow River, one of the most densely populated areas in the world.[239] But no disaster of that scale – killing millions and destroying the wealth of large populations – has been witnessed since. Communities have learned to protect themselves against the worst natural disasters.

Today, disaster risk reduction – steps to reduce the impacts of possible environmental catastrophes – is a well-developed field. So while the risks of extreme weather are expected to increase, we know where the most acute vulnerabilities lie, and measures exist to reduce risks and exposure to populations and their economies.[240]

Measures must be taken to avoid the worst tragedies. Disaster prevention still fails to mobilize adequate resources among the international donor community, which is more inclined to provide financial support to a community in the wake of a disaster rather than to prevent a disaster from occurring in the first place.[241] No measure of assistance after a disaster will restore lives lost in a large-scale disaster. The catalogue of possible actions provided in this chapter highlights how much more retroactive measures cost compared to proactive ones.

WHAT OVERWHELMS COMMUNITIES IS THE BREACHING OF A NEW THRESHOLD

Flooding in Pakistan. Source: UN Photo/WFP/Amjad Jamal.

THE REVIEW

Options for reducing the severity of weather-related disasters vary significantly in feasibility, cost-effectiveness, and expense. Most actions not only reduce our vulnerability to key climate risks but also help to reduce disaster risk overall.

Some of the most expensive alternatives, such as flood buffers and levees, can require millions of dollars of investment. Other alternatives, such as mangrove-planting and education campaigns, are relatively affordable although still clearly more expensive than most interventions we've looked at (in the health category, for example).[242]

The majority of possible measures provide no guarantee of reduced impacts, since sea or river walls are only ever as powerful as their weakest link.[243] Early warning systems may function perfectly, but a void in awareness of risks could result in millions in need of humanitarian assistance if precautionary guidelines are not adhered to.[244]

Nearly every available option has clear benefits beyond lessening the impacts of climate change. Enhanced weather forecasting to better anticipate storms and floods, for example, will also improve information to key industries, such as agriculture, energy, and transport.[245] Such measures will also help a community rebound from a catastrophe. For example, raised roads built with proper drainage and raised high enough to preserve their composition will allow for emergency assistance to be delivered where needed and will also enable the local economy to get its key trade nodes operational quickly after a crisis.[246]

Mangroves not only slow the wind speed of tropical cyclones. They also sequester carbon from the atmosphere, preserve biodiversity in wetland areas, and reduce the impact of sea-level rise on coastal environments. Mangroves also serve as natural flood barriers, since their roots reclaim sediment that might otherwise flow into rivers and cause flooding.[247]

Coastal barriers can play a major role in preventing the worst effects of sea-level rise and holding back storm surges. The more than USD 60 million sea wall enclosing the Maldivian capital of Male' proved crucial to its survival of the 2004 Indian Ocean tsunami.[248] In the long-term, however, sea walls can also be detrimental to the local environment by trapping saltwater inland and gradually reducing the fertility of adjacent soils through salination.[249]

The most expensive way to reduce the impacts of weather-related disasters, almost invariably, is providing emergency assistance to populations following a disaster. Here, costs may rise into the tens or hundreds of millions of dollars depending on the number of people in need of help. So investing before disasters occur should be the focus of any adaptation strategy focused on extreme weather.[250]

Lives are easier to save than infrastructure, and buildings can be reconstructed, where lives can never replaced. It is critical that any adaptation strategy ensure first and foremost the protection of highly vulnerable civilian populations.

Proactive measures for countering weather-related disasters are generally well documented, although no cost-effective measures relating to wildfires are included in the assessment. Most measures can be applied universally and can benefit all income groups.

TIMEFRAME CONCERNS

Reducing the impacts of extreme weather is going to require major strategic decisions. Some actions, like storm shelters or ensuring emergency evacuation procedures, are easily taught and followed and can offer protection in the relatively near term.[251] Other much more expensive multimillion-dollar disaster monitoring systems may be harder and costlier to implement and maintain but could save hundreds of thousands of lives.

Sea walls or riparian river buffers vary from simple, often weak mud flood levees to giant, kilometre-long concrete barrier systems. Such measures can take anywhere from a few days to several years to construct, and budgets range correspondingly from a few dollars to tens of millions.[252]

There is a need, therefore, to balance the choice of policies so that new measures can be implemented quickly in the most vulnerable communities, while more intensive, high-investment but high-return actions are implemented in parallel.

WEATHER DISASTERS **ADAPTATION ACTIONS**

	ACTION SET	VULNERABILITIES	MOST VULNERABLE POPULATIONS	EFFECTIVENESS RATING	EVIDENCE RATING
1	COMMUNITY-BASED LOCAL EARLY WARNING SYSTEMS	• Injuries • Loss of shelter and livelihoods		High	High
2	FORECASTING SYSTEMS	• Injuries • Loss of shelter and livelihoods		High	High
3	DISASTER-MANAGEMENT TRAINING PROGRAMMES (PREPAREDNESS)	• Immediate impact of extreme weather events		Very High	High
4	DISASTER RELIEF (LIMITED CARE)	• Injuries • Loss of shelter and livelihoods		High	High
5	FLOOD PROOFING OF HOUSES	• Physical damage due to floods		High	Low
6	FLOOD PROOFING OF ROADS	• Storms, floods		High	Medium
7	RIPARIAN BUFFERS	• Floods		High	Medium
8	MANGROVE PLANTING	• Floods		Medium	Medium
9	HURRICANE-RESISTANT HOUSING/SHELTERS	• Injuries, death • Physical damage due to hurricanes		Medium	High
10	FLOOD CONTROL	• Floods		High	High
11	PRE-POSITIONING OF ESSENTIAL ASSETS (COMMUNITY-BASED PREPAREDNESS)	• Human health		Very High	High

Children · General population · Elderly · Low-income populations · Urban populations · Livelihoods derived from fisheries and cash crops · Populations close to rivers · Populations close to coasts

COMMUNITY-BASED LOCAL EARLY WARNING SYSTEMS

1

Creating a system for communities to get knowledge of potential disasters before they happen and to disseminate warnings via local warning communication chains.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✓
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically after 6 months
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 1 Year

Expense: $1 million+ per system

Impacts Addressed: **Injuries, loss of shelter and livelihoods, damage to property**

Early warning system programmes rate highly on co-benefits. The system would benefit all groups in the focus area. The early warning system is cost-beneficial within one year if the local community is trained to react to early warnings and if monitoring infrastructure is properly maintained. Implementations will vary depending on weather patterns, location, and risk addressed, and must be complemented by appropriate capacity building in communities at risk, training of professional emergency services, and adequate resources to support preparedness and effective response.

The warning system is highly dependent on the local community's willingness to cooperate and act, and there must be adequate technical expertise on hand to maintain local weather stations and report data. The UN has developed guiding principles for such systems, and many training programmes are available.

The programme has high relevance for low-income countries, since more than 90 percent of natural disaster-related deaths occur in these countries. The interest for establishing local and low-cost early warning systems is growing, according to the German Technical Cooperation.

MDG BOOST ↑1

Sources: IFRC (2009), IFRC (2004), GTZ (2009), UN (2006), Plummer et al. (2003), WMO

Very low | Low | Medium | High | Very high

FORECASTING SYSTEMS

2

Involves technical monitoring of larger-scale weather systems, climate modelling and warning services, and communication of warnings.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✓	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically after 6 months
SCALABILITY	High				
EVIDENCE BASE	Very High	Long-Term	✓	Programme Cycle	Typically 1 year

Expense: $1 million+ per system

Impacts Addressed: **Injuries, loss of shelter and livelihoods, damage to property**

Forecast systems rate highly on co-benefits and can be considered cost effective. They inform local communities about potential weather disasters and are also beneficial to agricultural production and other sectors of the economy, resulting in improved quality of life. The systems benefit all groups in the focus area. However, due to differences in weather patterns and available technological services and funding, some communities will experience easier implementation and higher success rates than others.

The forecast systems can be considered cost-beneficial after approximately 8.5 years. However, as they become more efficient and less expensive, their overall cost-effectiveness should improve over time. The World Meteorological Organization coordinates more than 150 national, 35 regional, and 3 global meteorological centres that analyze data in near real-time to make forecasts and issue hazard warnings.

Forecast systems must be complemented by capacity building and a trained local community force (cf. Community-Based Early Warning). The programme will continue to be effective for as long as the systems are maintained.

MDG BOOST ↑1

Sources: IFRC (2009), UNISDR (2007), UNISDR (2005-2015), GTZ (2009)

DISASTER MANAGEMENT TRAINING PROGRAMMES (PREPAREDNESS) 3

Disaster preparedness is primarily a matter of building adequate shelter and human resources (not necessarily investing heavily in advanced technology and equipment).

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✓	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 1 year

Expense: $25,000-$100,000/programme

Impacts Addressed: **Immediate impact of extreme weather events**

Disaster preparedness programmes benefit all groups in the focus area, in addition to protecting and informing agriculture and other productive sectors important to a community's economy and well-being. Preparing populations for natural disasters is often under-prioritized in low-income countries due to a lack of funding.

Building adequate local shelter is one of the most cost-effective ways to improve the quality of national response and external aid in extreme weather events. The programme is quick to implement where educational facilities exist. And it is more cost-efficient to have trained personnel on the ground instead of relying on international aid.

The programme has wide implications for those affected by natural hazards and on how resources are allocated in emergency situations. Regarding the programme's feasibility, international training should be adapted to local conditions. If training and emergency preparedness is coordinated with relevant UN agencies and NGOs, programme results will be consistent. Thorough guidelines exist, and several NGOs and universities have developed training programmes. For example, Columbia University's School of Public Health has an online training centre that offers a variety of courses, tools, and other resources.

MDG BOOST ↑1

Sources: Columbia University (2010), DCP2 (2006), UNISDR (2007)

DISASTER RELIEF (LIMITED CARE)

4

Limited medical care in case of disaster. Includes treatment for infection and minor trauma. Also includes diagnosis, advice, pain relief, and treatment (as resources permit) for more complicated conditions.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✓	Quick Start	✓
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	✗
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✗	Programme Cycle	Typically 1 year

Expense: $25,000-$1,000,000 or more; per DALY: $253-$380 (low-income countries), $507-$760 (middle-income countries)

Impacts Addressed: **Personal injuries and disability**

Limited-care disaster relief programmes rate highly on cost-effectiveness because of their short- to medium-term duration. However, there is a risk of low cost-effectiveness in the cases where inappropriate in-kind donations are made. And bringing in outside health professionals can be less cost-effective than using local services.

Since the programme focuses on personal, limited care, co-benefits are low. However, in the case of natural disasters, medical care is relevant to all groups.

Emergency response efforts usually take place in a politically and emotionally charged climate. Often, the international community launches its own relief operations in the belief that local health services are incapable of handling the disaster. However, local health services are actually best situated to respond to health consequences of disasters in their communities.

WHO guidelines exist on a variety of disasters, and NGO training programmes are common. The programme is highly relevant, since low-income countries are more likely to experience a drop in GDP due to disasters. The World Bank, Red Cross, and WHO have published various peer-reviewed studies on the subject. And risk-management programmes are common in the Ministries of Health in low-income countries.

MDG BOOST ↑1, ↑6

Sources: DCP2, UNFCCC, NAPA Cambodia (2007)

FLOOD PROOFING OF HOUSES

5

Flood proofing of individual houses against the maximum flood level recorded in the past 20 years.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically after 2-3 years
SCALABILITY	Very High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 25 years

Expense: $144-244 per house

Impacts Addressed: **Physical damage due to floods, human health**

Programmes to promote the flood proofing of houses rate highly on co-benefits and scalability. Livelihoods and houses are improved and protected as a result of the programme. It is highly relevant to vulnerable groups in low-income countries and promotes consistent benefits for all households. Many UNFCCC and other case examples are available on the subject.

A flood-proofing programme is funded and rolled out over several years and can take 25 years to fully implement. However, it is relatively cost-effective over time, and after four years, the benefits exceed the costs. Also, results are consistent as long as the implementation is designed to fit local needs. If the programme is established correctly, results are consistent.

Policymakers currently show little interest in the programme, and peer-reviewed studies on the subject are limited. However, such programmes have been common in Bangladesh, where flood proofing by way of raising houses and other infrastructure is part of traditional practice. A house raising option programme in Bangladesh's main river char lands will provide raised households to some 2.5 million people.

MDG BOOST ↑1, ↑7

Sources: UNISDR (2007), Islam & Mechler (2007), Caspari & Pokhrel (2008)

FLOOD PROOFING OF ROADS

6

Flood proofing of roads and highways by raising road height to the highest recorded flood and providing adequate cross-drainage facilities.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically after 2-3 years
SCALABILITY	Medium				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Varies

Expense: $100,000-$200,000 per km of road

Impacts Addressed: **Flooding**

Programmes to flood proof roads rate highly on co-benefits. Benefits of the programme include preventing human and livestock deaths, using of the raised roads as refuges during floods, and providing a corridor for transporting relief goods during floods. Once a raised roads programme is implemented, resources can then be allocated to other flood-prone areas, and transportation will not be obstructed due to collapsed roads. The programme benefits all groups. Results are consistent as long as road standards are high.

Raising roads is a long-term programme implemented over stages and is only cost-effective in high-risk areas, where flooding is frequent. However, compared to the cost of full rehabilitation of roads ($70,000 per km), the programme (approximately $140,000 per km) is cost-effective over time.

Implementation requires funding and occurs over several years. However, it entails low risk, and results are consistent if the programme is established correctly. It is important to note that raised roads without proper drainage and careful planning could submerge poor households that do not have the capability or incentive to build up their own land.

In Bangladesh, approximately 170 km of national and regional roads and 518 km of local roads in high-risk areas will be raised. Since it is a long-term programme with very high costs, portions of roads will be raised when they are due for major maintenance, with priority given to high-risk areas.

There is a lack of well-documented training sources and case examples for this programme. However, comprehensive technical specifications and guidelines are available, and technical capacity often exists at the local level. The programme is highly relevant in low-income countries where roads already exist.

MDG BOOST ↑1, ↑7

Sources: UNISDR (2007), Islam & Mechler (2007), UNESCO (2009), IDS (2007), Caspari & Pokhrel (2008)

RIPARIAN BUFFERS

7

By impeding and absorbing flood waters, riparian forest buffers reduce flood damage. Riparian buffers also lower flood frequency because they reduce the amount of sediment flowing into rivers and streams that can make them prone to overflowing.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically after 2-3 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Varies, depending on technique used

Expense: $1,000,000+

Impacts Addressed: **Flooding, water quality**

Riparian buffer programmes rate highly on co-benefits, since they also protect water supplies and prevent widespread source pollution, benefiting all groups.

The programme received a lower rating for cost-effectiveness because some barriers (tree plantation vs. grass, for example) can take a long time to develop and can involve high tending costs. However, in the Feitsui reservoir watershed, there is a 1.245 benefit-cost ratio after a period of three years.

MDG BOOST ↑1, ↑4, ↑6, ↑7

Sources: UNISDR (2007), Chang et al. (2010), Caspari & Pokhrel (2008)

MANGROVE PLANTING

8

Mangroves can serve as buffer zones in front of sea dike systems, reducing water velocity, wave strength, and wind energy.

ASSESSMENT Medium

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically after 3 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 10 years

Expense: starts at $225 per hectare

Impacts Addressed: **Floods, storms, tsunami**

Mangrove-planting programmes rate highest on co-benefits and scalability. Planting mangroves in their native habitat restores coastal biodiversity (including fish and shellfish production), enhances water quality, and can protect homes, agriculture, and livestock from flooding.

The FAO and various NGOs have developed guiding principles for this kind of programme. The programme is highly relevant for coastal communities in low-income countries, which are most vulnerable to natural disasters. Various NGOs have developed training programmes and materials, but they are not always accessible.

The programme received a low rating for cost-effectiveness because, although restoration pricing varies, it can be high in some regions. Also, the full effects of restoration are felt only in the medium- or long-term. In Vietnam, $1 million was spent to replant 110 kilometres of mangrove forest. As a result, dyke maintenance costs have been reduced by $7 million per year.

In a number of cases, mangrove-planting programmes have reported low survival rates of plants. Once fully restored, however, mangroves are consistently effective against storm surges. Various peer-reviewed studies on the subject are available; however, they lack quantitative data and evidence of cost-effectiveness. There is also a lack of data directly quantifying the role of vegetation in mitigating hazards.

MDG BOOST ↑1, ↑7

Sources: PreventionWeb, Khazai et al. (2007), Lewis III (2001), Chan & Baba (2009), UNISDR

HURRICANE RESISTANT HOUSING

9

Prevention of damage to life and property, particularly by reducing how vulnerable a population's housing and community buildings are to floods and typhoons.

ASSESSMENT Medium

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	Medium				
FEASIBILITY	Very High	Short-Term	✓	Implementation Lapse	Typically after 2-3 years
SCALABILITY	Medium				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Varies, depending on extent of retrofitting/ construction

Expense: approximately $2,000,000

Impacts Addressed: **Floods, storms, tsunami**

Hurricane-resistant housing programmes rate highly for feasibility. They are successful if they are targeted at areas prone to seasonal storms, and should specifically target areas that have been assessed as vulnerable.

Co-benefits of hurricane-resistant housing or shelters include fewer personal injuries and material losses in seasonal hurricanes. In Vietnam, the houses of 1,300 low-income households were strengthened directly as a result of the programme. Recently, new construction has accounted for 60 percent of the houses completed through the programme, reflecting the weak state of housing. Families no longer bear the cost of hurricane recovery, enabling them to channel their budget to other activities.

There is high variability in the cost-effectiveness of this programme due to the uncertainty of storm impacts. However, retrofitting can still be cost-effective if it results in a 60% reduction in vulnerability for a cost not exceeding 5% of the initial building cost.

The programme received a low rating in scalability due to the lack of well-documented programme examples and available training.

There is an adequate evidence base for this programme. Many case studies address economic impact; however, few studies look at the cost-effectiveness of the programme.

MDG BOOST ↑7

Sources: UNISDR (2007), Stewart et al. (2003), World Bank (2009), UNDP (2007)

FLOOD CONTROL

10

Predicting floods in highly flood-prone areas and effectively intervening. Such a programme includes mapping of vulnerable areas, developing adequate drainage, and taking steps to prevent floods.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically after 0.5-1 years
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: from $13,000 - $900,000

Impacts Addressed: **Flooding, excess rainfall**

Flood-control programmes rate highly for scalability, cost-effectiveness, and co-benefits. There are many case examples available, and various NGOs and universities offer training programmes. The programme is cost-effective. In Bihar, India, a flood-control project that included physical interventions and capacity building had a cost-benefit ratio of 3.76.

The programme can be implemented in the short to medium term but will not reach a positive cost-benefit ratio until the long term.

In contrast to programmes that rely on structural measures for flood control, those that are "people-centred" appear to be highly resilient under a wide variety of conditions and are economically efficient.

Co-benefits are consistent in areas with seasonal flooding. Not all communities will have the local capacity to carry out an implementation. Programmes should be sensitive to social and cultural issues that can play a large role within the community.

MDG BOOST ↑1, ↑7

Sources: Oxfam/Tearfund (2004), Caspari & Pokhrel (2008), NAPA Bhutan (2006)

PRE-POSITIONING OF ASSETS

11

Build up food storage capacity and stockpile essential food and non-food items; set up and maintain community network awareness; and develop strategies for preparedness.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	Typically after 0.5 years
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✗	Programme Cycle	Typically 1 year

Expense: $388,000

Impacts Addressed: **Human health**

Programmes that pre-position assets rate highly on scalability, cost-effectiveness, and co-benefits. The Red Cross and other NGOs provide technical specifications and guidelines as well as training programmes. Many well-documented case examples also exist.

Compared to conventional procurement and disbursement of emergency supplies, the programme is highly cost-effective in the event of a natural disaster. Timing is of the essence when pre-positioning assets. Depending on the area in question, the programme is generally short-term.

All groups in a post-disaster environment benefit from such a programme, especially the poorest and most vulnerable. Factors such as facility location, inventory management, and network flows determine the impact and co-benefits.

The programme is logistically complex and assumes that disaster threats have been thoroughly assessed. Also, local infrastructure conditions (pre- and post-disaster) can limit the relief operation.

MDG BOOST ↑1

Sources: DCPP, Duran, Gutierrez, and Keskinocak (2010), NAPA, Tuvalu (2007), ReliefWeb (2009)

Workers construct a flood wall to protect buildings in the United States. Source: FEMA/Liz Roll.

HABITAT LOSS

Vast territories of the world and millions of its inhabitants are seriously exposed to desertification and sea-level rise.[253] Most of the measures used to counteract the effects of these trends involve major environmental management projects, which run into the millions or tens of millions of dollars and take years to implement. As more and more areas come under serious stress due to sea-level rise and desertification in the period through 2030, the costs of responding to those problems will increase. Given the fact that most programmes take time to deliver positive results, it is important to implement them quickly in areas where the impacts are currently the most extreme.

HIGH
Overall Effectiveness Rating

14 #Actions Assessed

FINDINGS

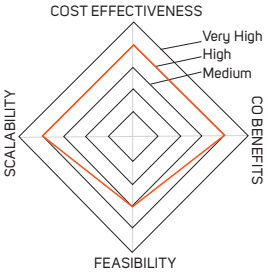
The impacts of desertification and sea-level rise are being felt around the world. In some of the larger countries, the number of people directly affected by desertification can run into the hundreds of thousands, even millions. Such populations are under extreme stress as their lands dry up and whole regions become unsuitable for productive use. Sea-level rise, meanwhile, affects the more than 1 million kilometres of the world's coastline and immediate hinterland.[254]

Only around 30-40 countries experience the main effects of desertification. The most intense impacts are taking place in Southern and West Africa. The largest populations at risk from desertification are in India, China, and the United States, which in 2010 have more than 2 million people threatened. This figure will rise to nearly 8 million by 2030.

Damage from rising seas is more widespread, since every coastline on the planet is affected. The worst effects are still quite concentrated in either relative (mainly small island states or river estuaries in Africa and Asia) or absolute terms (wealthy low-lying nations like Holland) and primarily affect fewer than 30 countries (aside from a number of very small island nations not included in our analysis). Where sea-level rise is most acute, its effects are final. Desertification and sea-level rise share many of the same effects, in particular the slow decimation of fertile soil, not only by heat and water stress, but also by salt intrusion into land and water supplies.[255] However, it is coastal land, not desert borderlands, that will completely disappear at a slow but unstoppable rate throughout the 21st century, eroding into the sea and not returning.[256]

Rapid and accelerating desertification is often caused by human activities linked to agriculture, in particular burning, over-grazing, over-cultivation, unsustainable deforestation, and over-exploitation of water supplies. Climate heat and water shocks worsen man-made land degradation in dryland regions and may further expose vulnerable communities that are dependent on ecosystems as a buffer

REVIEW FINDINGS



to climate-induced threats.[257] Growth of populations and economic activity compound these environmental pressures leading to desertification.

Tackling the loss of human habitat is still a pioneering field and is, in some cases, practically cost-prohibitive. One livestock management programme in Eritrea to protect some 1,000 people from the worst effects of desertification is estimated to cost USD 5 million for three years of protection.[258] For sea-level rise the costs can be even higher, but so can the losses. Consider the USD 10 billion per year cost that China already faces or the nearly 30% of GDP potential of Guinea-Bissau.

With expenses so high, the international community may soon have to choose which communities will be protected and which must be relocated. Migration can be considered a cost-effective adaptation tool where habitat loss hits hardest. The cultural cost to communities would be severe. Most of us today simply cannot fathom the total relocation of entire island or dry-region communities.

IF MEASURES ARE IMPLEMENTED ADEQUATELY, A NUMBER OF PROGRAMMES WILL CONTINUE TO DELIVER BENEFITS FOR DECADES TO COME

THE REVIEW

The most promising measures to counter the effects of habitat loss are, overall, less cost-effective than measures to manage other climate-related problems, such as disease and extreme weather.

The cost of habitat-loss intervention is typically measured in the millions and often involves a serious capital outlay that is not directly tied to a private commercial concern. So the building of a sea wall, the planting of trees, or the elevating of key infrastructure by several metres is a costly method of protecting populations and their assets when compared to other measures assessed in this report.[259] Some of the cheapest actions assessed here include a half million dollar effort to conserve and restoration of vegetative cover (such as dryland grasses) in areas threatened by desertification and a 1 million dollar per-implementation programme to restore mangrove forests in coastal areas.[260] Upgrading drainage systems threatened by coastal flooding, however, can cost USD 20 - 40 million.[261] Despite such expenses, several studies have documented that such actions are still cost-effective compared to the potential losses.[262]

Just as desertification is caused by factors other than climate change, the measures to combat it also protect populations from wider concerns.[263] This is less true for actions that address the effects of sea-level rise. In fact, many measures in this area actually have negative effects on the environment. Coastal barriers, for example, reduce tidal flow from the sea, trapping water inland and forcing more salt into the soils of the littoral, rendering even more land unfertile.[264]

Poor communities will rarely be able to access the type of long-term, infrastructure-intensive adaptation measures required to protect against habitat loss. This means the worst-affected communities are particularly dependent on international assistance in order to adapt and not be displaced from their homelands.

Scalability of habitat-loss programmes, however, is made easier by the fact that such programmes have typically been implemented a number of times before, so technical specifications and training programmes are usually available.

Despite isolated good examples, however, evidence indicates that most actions rate low on cost-effectiveness. Interventions are complex, and it's difficult to make any generalizations regarding the costs involved, so effectiveness often needs to be assessed on a project-by-project basis. Several implementation risks are also of concern, such as extreme weather hazards to beach extension/nourishment projects, or land-use conflicts among local communities of farmers and fishermen in cases of dryland restoration programmes or mangrove plantation efforts.[265] More quantitative information would help local policy-makers and communities prioritize their efforts to adapt to desertification and sea-level rise.

MEASURES TO COMBAT DESERTIFICATION ALSO PROTECT POPULATIONS FROM WIDER CONCERNS

TIMEFRAME CONCERNS

Almost every programme assessed here takes two to five years to implement. With only a handful of exceptions, most measures that address habitat loss take several years to put in place. Given that many vulnerable countries have yet to implement such projects, millions of people are currently either suffering serious economic losses –particularly populations that depend on agriculture for their livelihoods – or are being forced to flee the worst-affected zones.[266]

If measures are implemented adequately, however, a number of programmes will continue to deliver benefits for decades to come and will show long-term returns on the initial capital outlay. Forests of mangroves or dryland trees, for instance, will continue to deliver benefits for more than 20 or 30 years. Robust sea walls, if well maintained, could protect for a century or more against coastal risks.

Dead trees form an eerie tableau on the shores of Maubara Lake in Timor-Leste. Source: UN Photo/Martine Perret.

HABITAT LOSS **ADAPTATION ACTIONS**

	ACTION SET	VULNERABILITIES	MOST VULNERABLE POPULATIONS	EFFECTIVENESS RATING	EVIDENCE RATING
1	COASTAL PROTECTION (SEA WALLS AND DIKES)	• Inundation (loss of dryland) • Erosion (direct and indirect change)		Medium	Medium
2	BEACH NOURISHMENT	• Inundation (loss of dryland) • Erosion (direct and indirect change)		High	High
3	MANGROVE BARRIERS AND RESTORATION	• Saltwater intrusion		High	Very High
4	"BACK-AWAY" ELEVATION	• Erosion (direct and indirect change)		High	High
5	SALTWATER-INTRUSION BARRIERS	• Saltwater intrusion		Medium	Medium
6	LAND-USE PLANNING	• Wetland loss (and change)		Medium	Medium
7	DRAINAGE SYSTEMS UPGRADE	• Rising water tables and impeded drainage		Very High	High
8	CONSERVATION AND RESTORATION	• Desertification		Medium	Medium
9	SOIL CONSERVATION	• Desertification		High	Very High
10	FORESTATION	• Desertification		High	Very High
11	ENHANCED LIVESTOCK MANAGEMENT	• Desertification		Medium	Low
12	INTEGRATED COASTAL MANAGEMENT	• Wetland loss (and change)		Medium	Medium
13	POLDER CONSTRUCTION	• Rising water tables and impeded drainage		Medium	Medium
14	RELOCATION/ NEW HOME IMPROVEMENT	• Sea-level rise, flooding, typhoons		High	Medium

 Population in low-elevation zones  Dryland populations  Farmers

COASTAL PROTECTION (SEA WALLS AND DIKES)

1

Create coastal sanctuaries to act as buffers to extreme climate-related events

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	Typically after 2-5 years
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	5 years

Expense: $1 million +

Impacts Addressed: **Sea-level rise, flooding, coastal erosion**

Coastal protection programmes rate highly on co-benefits and scalability. The programme benefits human health and food security and targets all groups regardless of income. In Mozambique, a five-year coastal management programme is expected to positively impact biodiversity, agriculture, and water supply and sanitation.

Programme descriptions are available through the UNFCCC NAPA database, and many training programmes exist. The programme is also cost-effective, with a cost-benefit ratio of 1.2 for sea walls and 1.4 for dikes. Implementation is relatively consistent and occurs over a two- to five-year timeframe.

Several implementation risks are associated with the programme, including extreme climatic events during the construction of protection barriers, loss of access to beaches, and a potential for tourism decline.

Many studies are available through UNEP, UNFCCC, and the World Bank. The programme could benefit from further quantitative assessment.

MDG BOOST ↑1, ↑4, ↑5, ↑6, ↑7

Sources: ECA Working Group (2009), NAPA, Mozambique (2008), Cazenave & Llovel (2010), NAPA, Benin (2008), NAPA, Cape Verde (2007)

BEACH NOURISHMENT

2

Beach stabilization, wetland rehabilitation, and extension of beaches to absorb storm surge.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	Typically after 3 years
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $2 million +

Impacts Addressed: **Sea-level rise, flooding, coastal erosion**

Beach nourishment programmes rate highly on cost-effectiveness, co-benefits and scalability. Although cost consistency is dependent on local cooperation and available resources, the cost-benefit ratio is 0.2, and implementation can occur in as little as three years.

Co-benefits include protection against erosion and sea-level rise and are consistent where the programme is successfully implemented. The programme targets all groups regardless of income. In The Gambia, programmes to improve coastal defences are also expected to improve livelihood security and preserve biodiversity and ecological assets. For example, rehabilitation of the Kotu stream will prevent flooding of homes and restore rice cultivation.

Technical specifications and guidelines are readily accessible. Training programmes exist, and there are some well-documented case examples. Peer-reviewed studies are available from UNEP, UNFCCC and the World Bank. The programme could benefit from greater quantitative assessment and the development of more training programmes.

MDG BOOST ↑1, ↑7

Sources: ECA Working Group (2009), Nicholls et al. (2007), NAPA, Gambia (2008)

MANGROVE BARRIERS AND RESTORATION

3

Replanting mangrove forests in degraded areas to protect coastal areas from storms.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically after 2-4 years
SCALABILITY	High				
EVIDENCE BASE	Very High	Long-Term	✓	Programme Cycle	Typically 7 years

Expense: $1 million +

Impacts Addressed: **Sea-level rise, flooding, coastal erosion**

Mangrove barrier and restoration programmes rate highly on cost-effectiveness, co-benefits, and feasibility. With a 0.0 cost-benefit ratio and an implementation timeframe of three years, the programme is highly cost-effective.

The programme ranks high in co-benefits, targeting all groups regardless of income. In Cambodia, a mangrove restoration programme will protect neighbouring areas from windstorm, seawater intrusion and coastal erosion; enhance biodiversity; and reduce poverty through increased job opportunities. Additionally, recent evidence has shown that mangrove forests reduce vulnerability to tsunami damage.

Although the programme receives a high rating for feasibility, it may encounter problems with land availability and conflicts over land use. Weak social capital in local communities is also a barrier, posing a potential risk to ongoing projects.

Programme specifications and guidelines are available through the UNFCCC NAPA database. NGOs and universities do offer training programmes, but they are not all accessible to the general public.

MDG BOOST ↑1, ↑7

Sources: ECA Working Group (2009), NAPA, Cambodia (2008), NAPA, Congo (2006), NAPA, Djibouti (2006), OXFAM/ Green Coast Nicholls et al. (2007), World Bank (2008)

"BACK-AWAY" ELEVATION

4

Restrict all new buildings to at least a four-meter elevation ("back away").

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically within 1 year
SCALABILITY	Medium				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Varies

Expense: Unknown

Impacts Addressed: **Sea-level rise, coastal erosion (direct and indirect)**

"Back-away" elevation programmes rate highly on cost-effectiveness, co-benefits, and feasibility. With a 0.0 cost-benefit ratio, and implementation possible within one year, the programme is highly cost-effective. In Samoa, cost-benefit analysis revealed that 54 percent of the damage expected to occur in 2030 during a 250-year coastal flooding event can be averted by a set of four cost-efficient adaptation measures, including elevation programmes. Co-benefits include the improvement of livelihoods, prevention of saltwater intrusion, and enhancement of fresh water quality.

Extreme weather conditions or local policy conflicts may impact the programme's success. In Samoa, implementation of a mandatory land-use plan could cause conflict between central authorities and local chiefs. Also, geographic variance, even at a local level, can make back-away elevation impossible in some areas.

Various peer-reviewed studies and qualitative assessments are available through the World Bank, UNFCCC and UNEP. The programme could benefit from additional case examples and more training programmes to better ascertain its broad effects.

MDG BOOST ↑7

Sources: ECA Working Group (2009), Nicholls et al. (2007)

SALTWATER INTRUSION BARRIERS

5

May include construction of irrigation wells, development of integrated watershed management programmes, construction of structures to conserve soil and water, groundwater monitoring, and capacity building to protect freshwater sources.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically after 3 years
SCALABILITY	Medium				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $5 million +

Impacts Addressed: **Sea-level rise, saltwater intrusion**

Saltwater intrusion barrier programmes rate highly on co-benefits by improving livelihoods and fresh water quality and protecting coastal agriculture. In Eritrea, a groundwater-recharging project is also expected to improve wildlife habitats, food security, and health and nutrition, and to reduce poverty.

Programme costs are initially high, with results in the long term. Consistency of costs depends on available funds and local capacity. The feasibility of the programme may be hindered by a lack of existing national legislation on the proper use of groundwater, delays, budget shortages, and/or extreme weather conditions. The programme's success depends on commitment at both the community and policy-making level.

Various peer-reviewed studies and detailed qualitative assessments are available through the World Bank, UNFCCC and UNEP. The programme could benefit from more accessible technical specifications and guidelines and from additional training resources.

MDG BOOST ↑1, ↑7

Sources: ECA Working Group (2009), Nicholls et al. (2007), NAPA, Eritrea (2007)

LAND USE PLANNING

6

Land use planning is the term given to public policy that directs how land in a community is used, while balancing the needs of the people who live in the area with the environment. It involves studies and mapping, multi-stakeholder dialogue, and formulation of alternative land-use decisions.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically after 3 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $1 million +

Impacts Addressed: **Sea-level rise, rising water levels**

Land use planning programmes rate highly on co-benefits and scalability. The programme targets all groups, regardless of income, and serves to improve biodiversity and food security. In Cuba, national land use planning and management are integrated with disaster risk reduction, contributing significantly to the management of fragile coastal areas. High-risk coastal settlements were identified by producing hazard and vulnerability maps, and land-use regulations for retrofitting, resettlement, and urban growth were developed.

The programme has many strong, well-documented case examples. Technical specifications and guidelines are widely accessible. The programme is relevant to low-income countries and mega-cities in medium-income countries.

Costs for the programme are high, and there is no clear cost-benefit ratio. Long-term implementation is necessary before effects can be seen. Feasibility is highly dependent on the political context. The process often involves competing interests and values, so a high level of cross-sector cooperation is essential. Lack of funds and technical capacity can also hinder programme implementation.

Various peer-reviewed studies and detailed qualitative assessments are available through the UNFCCC and UNISDR. The programme could benefit from additional training resources and quantitative assessment of the programme's impact.

MDG BOOST ↑1, ↑7

Sources: ECA Working Group (2009), UNISDR (2007), NAPA, Ethiopia (2008), Nicholls et al. (2007)

DRAINAGE SYSTEMS UPGRADE

7

Increase capacity of existing drainage systems to handle more frequent storms, increased rainfall, and rising sea-level.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 1-2 years
SCALABILITY	Medium				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $20-$50 million

Impacts Addressed: **Rising water levels and impeded drainage**

Drainage system upgrade programmes rate highly on cost-effectiveness and co-benefits. The cost-benefit ratio is 0.33 for drainage system maintenance and 0.29 for drainage system upgrade projects. Implementation is possible within a year. However, depending on the magnitude of the project, a one-two year implementation timeline is also possible. The programme targets all groups and may reduce the prevalence of diarrhea, malaria, waterborne diseases and malnutrition, although more research is needed in this area.

In Bolivia, expansion of sewerage networks into low-income areas and construction of new wells is expected to have significant positive impacts on public health by improving access to clean water.

The programme's feasibility may be threatened by a lack of external funding and a lack of cooperation on local and policy-making levels. Also, extreme weather conditions may postpone or even destroy existing projects.

The programme is relevant to middle and high-income countries in addition to low-income countries. The World Bank, UNFCCC, and UNEP have published studies on such programmes, and robust quantitative assessments have been performed for some projects. However, few examples of technical specifications and guidelines exist, and training resources are scarce.

MDG BOOST ↑1, ↑4, ↑5, ↑6, ↑7

Sources: ECA Working Group (2009), World Bank (2005), GEF (2010)

CONSERVATION AND RESTORATION

8

Reforesting, replanting, restoration, and rehabilitation of existing woodlots in degraded areas using native, drought-resistant forest species.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically after 2-3 years
SCALABILITY	Very High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 4 years

Expense: $500,000

Impacts Addressed: **Desertification**

Conservation and restoration programmes rate highly on co-benefits, scalability, and feasibility. Co-benefits include improvements in biodiversity, human health, and food security. In Burundi, the long-term results expected from the program include reconstruction of hydrological and weather-regulation systems and increased agricultural production.

The programme is very relevant to low-income countries and has many well-documented case examples. For example, the "Conservation and Rehabilitation of African Lands" programme recognizes the importance of vegetative conservation and restoration and prioritizes actions for managing forest resources and rehabilitating plants to control desertification.

The programme shows consistent results where implemented. As the project involves several sectors, feasibility is highly dependent on strong coordination between local partners. Also, poverty may drive local populations to clear restored forest areas.

Further information is needed to determine the programme's cost-effectiveness.

Several high-profile empirical studies have been done. Although there is already relatively high recognition at the policy-making level, the programme warrants increased attention in the future.

MDG BOOST ↑1, ↑7

Sources: UNCCD (2004), NAPA, Rwanda (2007), NAPA, Burundi (2007), Waithaka et al. (2010)

SOIL CONSERVATION

9

Conserve soil by building infiltration ditches around homes, planting grass cover, using terrace farming, digging trenches to divert runoff, mulching, and tree planting. Such projects reduce the vulnerability of regions affected by erosion and floods.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically after 4-5 years
SCALABILITY	Medium				
EVIDENCE BASE	Very High	Long-Term	✓	Programme Cycle	Typically 8-9 years

Expense: $1 million +

Impacts Addressed: **Desertification**

Soil conservation programmes rate highly on cost-effectiveness and co-benefits.

The cost-benefit ratio of the project is -0.2. Co-benefits include improvement of infrastructure and protection against floods. In Rwanda, the programme is also expected to stem migration of populations in search of suitable land for agriculture.

The programme is highly relevant to low-income countries. Awareness programs, education, and training in resource use addressed to farmers, local offices, and ministries of agriculture have been developed. A few well-documented case examples from Sub-Saharan Africa exist.

The amount of funding and technical expertise available may affect the programme's feasibility. Also, land policy, actual land occupancy, and complex farming practices may hinder implementation. Several high-profile empirical studies are available, and there is relatively high recognition for the programme, but more attention is needed in the future.

MDG BOOST ↑1, ↑7

Sources: ECA Working Group (2009), NAPA, Burundi (2007), NAPA, Rwanda (2007), Waithaka et al. (2010)

FORESTATION 10

Establishing forests, naturally or artificially, on areas that may or may not previously have been forested.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically within 3 years
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $5 million

Impacts Addressed: **Desertification**

Forestation programmes have a wide range of co-benefits, are easy to scale up, and are cost-effective and feasible. The programme also positively impacts agriculture, food security, and desertification. In Uganda, where forestry contributes to economic development and general well-being, increased employment opportunities are expected to be a significant by-product of forestation.

UNCCD's globally launched Thematic Programme Networks (TPNs) provide extensive technical specifications and guidelines. Also, the "Mediterranean Forest Action Programme" (MED-FAP) intends to address the main problems related to sustainable management of plant formations and the promotion of forestry in controlling desertification in the Mediterranean region.

The cost-benefit ratio is between 0 and 1 for medium-income households. Results will only occur in the long term, as the project requires tree growth. Project costs will vary based on geography. Forest plantations in arid and semi-arid zones may have few beneficial effects unless they are closely related to the needs and priorities of the local population. So it is important to integrate forestation into farming systems not only for the purpose of growing trees but also to improve the welfare of rural families.

Successful implementation can be undermined by insufficient funding and limited knowledge as well as by natural hazards, pests, and civil conflicts.

MDG BOOST ↑1, ↑7

Sources: NAPA, Rwanda (2007), Waithaka et al. (2010), Dahal (2006) , NAPA, Burundi (2007), UNCCD & Joint Liaison Group of the Rio Conventions (2007), NAPA, Uganda (2007), UNCCD (2004)

ENHANCED LIVESTOCK MANAGEMENT

11

Enhance the ability of livestock production systems to adapt to changing climatic conditions, such as drought and strong inter-annual precipitation

ASSESSMENT Medium

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	Typically after 3 years
SCALABILITY	Medium				
EVIDENCE BASE	Low	Long-Term	✓	Programme Cycle	Typically 4 years

Expense: $5 million+

Impacts Addressed: **Desertification**

Enhanced livestock management programmes rate highly for co-benefits. This programme is applicable to all groups, regardless of income, and enhances biodiversity and food security. In Uganda, a drought adaptation project includes promotion of a suitable, community-led livestock and animal-products marketing system. In the long-term, the project is intended to restore household food security, improve the quality of food consumed, and increase household income.

The programme requires close cooperation between farmers and local agencies. Potential barriers to this programme include inadequate funding and insufficient community participation. In Eritrea, programme challenges have included limited access to technical know-how at the local level and little ability to increase livestock production through best use of available resources.

The programme is highly relevant in low-income countries. Training programmes exist through UNDP country offices and local NGOs. The cost-effectiveness of the programme has not been determined. However, the programme could benefit from additional case studies and cost-benefit analyses.

MDG BOOST ↑1, ↑7

Sources: LDCF/NAPA (2007-2009), NAPA, Eritrea (2008), Waithaka et al. (2010), UNFCCC, LDC Expert Group, GEF (2009)

INTEGRATED COASTAL MANAGEMENT

12

Increase the resistance capacity of coastal zones through integrated management of coastal resources. Includes experimenting with a variety of construction materials, alternative means of construction, local early warning systems, and training.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically after 5 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Varies

Expense: $1 million +

Impacts Addressed: **Sea-level rise, wetland loss (and change)**

Integrated coastal management programmes rate highly on co-benefits and scalability.

Co-benefits include improved ecosystems, infrastructure, and economic activities. People are also less likely to be displaced from their communities. An integrated management programme in Cape Verde will also support economic development by supporting tourism infrastructure located in coastal areas.

The programme is especially relevant to small island nations. Technical specifications and guidelines are generally available through the implementation programme. Training programmes and information are available through the NAPA project "Adaptation to Climate and Coastal Change in West Africa".

The cost-effectiveness of the programme has not yet been clearly determined. The programme may be unfeasible due to a lack of external funding, which is critical to implementation. Also, extreme weather conditions may postpone or hinder the implementation process. Peer-reviewed studies and detailed qualitative assessments are available through UNFCCC.

MDG BOOST ↑1, ↑7

Sources: NAPA, Cape Verde (2007), Nicholls et al. (2007)

POLDER CONSTRUCTION

13

Construction of small or large polders to prevent the water table within the polder from rising too high.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically after 3 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 8 years

Expense: $1 million +

Impacts Addressed: **Rising water tables, Coastal inundation**

Polder construction programmes rate highly on cost-effectiveness, co-benefits and scalability. The project is considered cost-effective and usually has a three-year implementation timeframe. In addition to reducing flooding, polder restoration projects improve and restore biodiversity and human health and increase agricultural production.

Few technical guidelines are available for this programme. Training programmes, however, are available through IPCC and Caritas International. Roadblocks to successful programme implementation include a lack of awareness at the community and policy-making level and a lack of technical assistance and tools. The programme is also sensitive to weather changes, such as extreme sea-level rise or flooding. In Bangladesh, drainage congestion due to sea-level rise and inundation has been identified as a threat to polder performance.

Peer-reviewed studies and detailed qualitative assessments are available through IPCC. The programme could benefit from further cost-benefit analyses and increased awareness as well as momentum to implement the programme in local and national planning projects.

MDG BOOST ↑1, ↑7

Sources: Mohal, Kahn & Rahman (2007), NAPA, Bangladesh (2005)

RELOCATION/NEW HOME IMPROVEMENT AND ELEVATION

14

Elevating new homes on concrete piles, securing roofs with metal straps and nails, or relocating highest-risk homes to safer locations.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically after 1 year
SCALABILITY	Medium				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Varies

Expense: $500,000

Impacts Addressed: **Sea-level rise, flooding, typhoons**

Programmes that target relocation/improvement and elevation of homes rate highly on cost-effectiveness and co-benefits. Implementation is possible within one year, and benefits are long-term. The cost-benefit ratio for elevating new homes is 0.33, while elevating prioritized homes for retrofitting is 2.77. Co-benefits include the improvement of human health and socio-economic conditions due to a safer environment and lower risk of losing homes and/or livestock.

Successful implementation hinges on awareness at the community and policy-making level. In cases of extreme flooding, there is a risk that elevated homes may still be risk-prone.

Peer-reviewed studies are available through UNFCCC; however, the programme would benefit from additional case studies and quantitative assessment. Further studies would also serve to heighten awareness of the programme among policy makers.

MDG BOOST ↑1, ↑7

Sources: ECA Working Group (2009), NAPA, Eritrea (2007), NAPA, Sao Tome e Principe (2008)

ECONOMIC STRESS

For economic growth to continue in countries worst affected by climate change, it is crucial that they be able adapt to the most serious economic stresses. The poorest communities will rely on external assistance. Several major concerns, such as mass global shifting of fish stocks and coral destruction, are unlikely to be preventable to any meaningful degree by the types of local actions that are currently available. There will be further limits to adaptation on the frontlines of scorched dryland regions that receive less and less rain.[267] However, a number of effective responses could have extended benefits for socio-economic development that might far outweigh the negative effects of climate change in the near future. Adaptation to climate stresses should be seen as an opportunity to sustain the fight against the worst forms of rural poverty and hunger.

HIGH
Overall Effectiveness Rating

19 #Actions Assessed

FINDINGS

The economic cost of climate change is perhaps the least understood aspect of the climate challenge and the most difficult to gauge. Significant changes in air temperature, water temperature, rainfall, river flows, and ocean acidity will have wide-reaching effects on the environment and the economy but have not been documented in a way that enables us to fully quantify those effects.[268] It is difficult to forecast outputs and prices in agricultural markets even without factoring in climate change. Many other considerations, such as population growth, general economic activity, and resource inputs, also play into the equation.

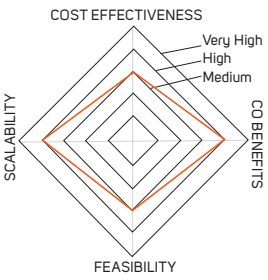
In some cases, climate change is projected to lead to net benefits in the near term.

But most often it implies net costs. Many industries are already adapting to the changes regardless of whether they are of a beneficial or a negative nature.[269]

While all sectors of the economy will feel the changes, agriculture, forestry, fishery and other primary sectors will be most affected. These sectors will reap most of the benefits but will also be hit with most of the negative effects of climate change. The effects on these sectors will also be passed on to other parts of the economy and to society as a whole.

In some cases, climate change is projected to lead to net benefits in the near term
The focus of this report is on helping areas that

REVIEW FINDINGS



THE ECONOMIC COST OF CLIMATE CHANGE IS PERHAPS THE LEAST UNDERSTOOD ASPECT OF THE CLIMATE CHALLENGE

will face the negative impacts of climate change to minimize those risks, not to advise economies profiting from climate change (those in the far north or south) on how to better reap the benefits. It is not within the scope of this report, however, to document all possible responses to all possible negative impacts. When assessing the economic stresses caused by climate change, the serious effects being felt by high-altitude or high-latitude communities due to thawing permafrost, for example, have not been taken into account. As once permanently frozen land thaws, all manner of infrastructure, from roads and bridges to homes and electricity grids, become destabilized and unsafe. The associated adaptation costs are overwhelming on a local basis. The cost of moving just one small village in Alaska, for example, has been estimated at over USD 50 million.[270]

The number of people suffering permafrost-type impacts is dwarfed by the number who, in the next 20 years, will be affected by severe productivity drops in crop production, livestock rearing, forestry and the fishing industries in warmer parts of the world. This report assesses some of the more effective responses available to these communities.

IN SOME CASES, CLIMATE CHANGE IS PROJECTED TO LEAD TO NET BENEFITS IN THE NEAR TERM

THE SUMMARY

The measures assessed in this report that relate specifically to reducing economic stress received generally high ratings for effectiveness and testify to a range of promising options already available to seriously reduce some of the main economic impacts of climate change.

Measures taken to help communities adapt to economic stress can be very costly and must be justified in the local economic context. Programmes generally range from around USD 100,000, such as for a groundwater prospecting and extraction project, to over USD 5 million for an integrated pest management scheme.[271] Governments will often have to provide significant support to help farmers and fisher folk adapt to these stresses.

The most options available relate to crop and livestock based agriculture and water stress situations. Fewer options were found for limiting impacts to the forestry and fishery sectors, based on the research behind this report. Even fewer options are available to combat major threats to land-based biodiversity, such as in rapidly warming mountainous or Polar regions.

Changes in crop management are among the simplest measures for fighting off heat, drought, water scarcity or salt intrusion in soils due to climate change. The use of newly available drought-resistant plants or simple changes in planting dates can improve yields in certain circumstances.[272] Coastal communities can also plant crops that can be irrigated with seawater alone for the price of a pump (or around USD 600 per acre). But salt-resistant crops are generally only suitable for livestock feed and yield lower returns than other cash crops.[273]

The world's poorest farmers struggle to obtain access to high-quality fertilizers and seeds, with many surviving on the least productive varieties available. These plant types will make less and less commercial sense in the world's most marginal regions as a result of climate change, forcing a switch to higher quality seeds and plant varietals. This could ultimately bring about a surge in agricultural productivity that well outweighs the negative impacts of climate change.[274] Many low-income farmers will not have resources to make the switch for the same reasons they have been unable to gain access to better supplies in the past.

Another cost-effective alternative for irrigated crops is switching to drip irrigation. This entails feeding small drops of water through tubing directly onto plants, minimizing wastage and evaporation, but again requiring installations over and above the means of most worst-affected farmers, with projects assessed here ranging from USD 100,000 to 400,000.[275]

In many cases, simply upgrading services available to farmers could help to minimize many negative impacts of climate change. In parts of Africa and Asia, for example, the most basic weather-monitoring networks are often inadequate. Additional automatic weather stations on the ground are cheap and effective and can help farmers make crucial decisions while also enabling disaster forecasting and delivering other commercial benefits.[276]

In many areas, pests and fires will increasingly threaten forests, and coastal erosion will threaten mangroves.[277] Pest management is assessed as a highly effective response here, but it also carries a high cost.[278] Other forest or mangrove plantation conservation programmes are highly effective and much less costly to implement. Sustainably managed forests and mangrove plantations also result in significant benefits to biodiversity.[279]

Proactively collecting and storing rainwater can compensate for shrinking water availability even in areas where rain will continue to decline. But collected water has to be carefully managed in order to last through extended periods of drought.[280] In the driest regions, the annual rainfall may no longer suffice for larger communities, in which case, prospecting for new sources of groundwater, sometimes far away, may be the only alternative to relocation.

Conservation-type programmes are among the best-documented measures to reduce the economic impact of climate change on fisheries. Projects include the creation of marine sanctuaries to allow aquatic life to regenerate, and monitoring and re-propagating threatened coral or shellfish. It's unclear how well such initiatives would function on a large scale.[281]

The feasibility of implementing any of the measures assessed here to counter economic stresses is a major concern. Above all, the costs are over and above the means of worst-affected communities, which makes implementation unlikely without deliberate external funding. And while a quarter-of-a-million dollar shellfish programme may prove fruitful for a three-year duration to a local island community of a few thousand people in the South Pacific, extending that programme to millions of stressed marine environments and coastal communities around the world would be a massive undertaking.[282]

A number of the actions assessed in this report will also require legislative changes, for example through establishing conservation areas, or involving local government services, such as with the improvement of weather monitoring networks. In areas where the institutional frameworks of government are already stressed, this will make implementation very difficult.[283]

Forest, mangrove, and marine conservation or enforced sustainable practices, may also run into competing commercial interests within communities, which might cause short-term risks to food security, if, for example, local fishermen are suddenly prohibited from wetland or coastal fishing.[284]

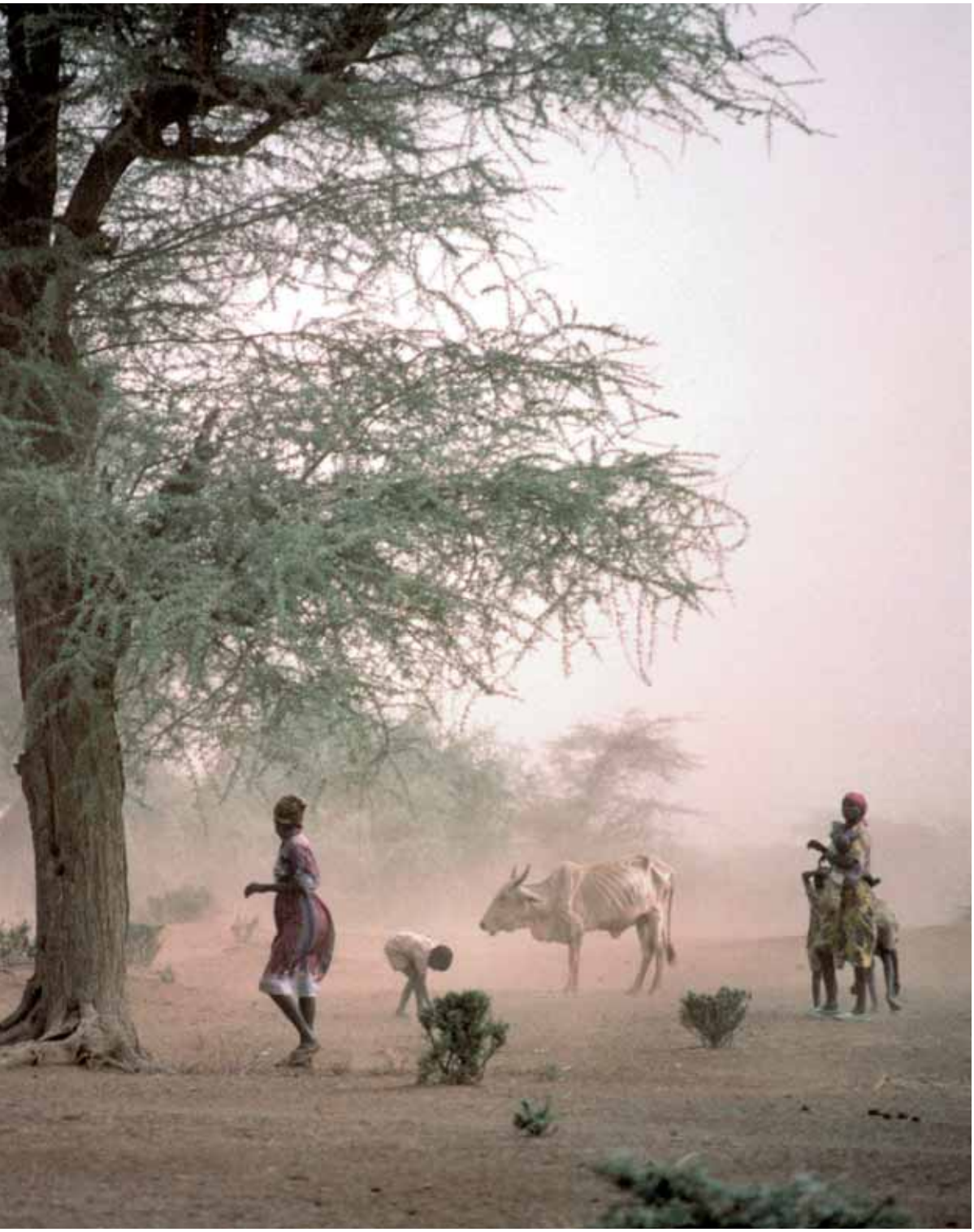
However, a number of the measures assessed here could unlock new potential across value chains if properly implemented, particularly for poor rural communities. Proper weather monitoring, for example, is a prerequisite for insurance plans based on indexes of meteorological information that are affordable even to the poor, since they pay out when rainfall drops below a certain level and do not require costly assessment procedures. Insurance can in turn facilitate access to microfinance, and microfinance can lead to the procurement of better seeds, fertilizers and other supplies. In successful cases, therefore, benefits of some of the responses assessed here could be wide-reaching.

Some of the actions assessed here are long familiar to agricultural or development communities. It has been well documented, for example, that improved roads and seeds result in higher rural output levels. These initiatives are easily replicated anywhere and will widely benefit communities in most cases. However, a number of measures, such as introducing salt-water crops, are pioneering responses to emerging concerns, and we are only beginning to see case examples that would serve as a foundation for widespread implementation.[285]

TIMEFRAME CONCERNS

A number of the measures here can be implemented almost immediately, such as installation of weather monitoring networks or even the launch of a coral or mangrove conservation programme. Such actions, however, may take much longer, often years, to achieve a positive impact.[286] Marine life may bounce back fast (as with some examples of coral reef damage) or take decades to properly regenerate even if left completely undisturbed by commercial operations. Desalination plants or micro-irrigation systems are quick fixes by comparison that will continue to reap benefits for years, although maintenance and running costs will need to be met.

Concrete water storage facilities on the other hand, may require more than a year to construct and link to local water systems. But the lifetime benefits of such systems could continue to be enjoyed by communities for much more than 10 years with only minimal maintenance



A sandstorm on the western shore of Lke Baringo, Kenya. Source: UN Photo/Ray Witlin.

ECONOMIC STRESS **ADAPTATION ACTIONS**

	ACTION SET	VULNERABILITIES	MOST VULNERABLE POPULATIONS	EFFECTIVENESS RATING	EVIDENCE RATING
1	DRIP IRRIGATION	• Agriculture • Water scarcity		Very High	High
2	SOIL CONSERVATION	• Drought, Water Scarcity		Very High	Medium
3	CROP ENGINEERING FOR DROUGHT RESISTANCE	• Agriculture • Water stress		Very High	High
4	DRAINAGE SYSTEMS	• Agriculture • Water stress		Very High	High
5	RAINWATER HARVESTING	• Water scarcity		Very High	High
6	WATER STORAGE FACILITIES	• Water scarcity		High	High
7	CANAL LINING	• Water scarcity		Medium	Medium
8	INTEGRATED PEST MANAGEMENT (IPM)	• Agriculture • Declines in projected yields • Length of growing season		High	High
9	GROUNDWATER MANAGEMENT	• Water scarcity		Very High	High
10	MANGROVE RESTORATION AND PROTECTION	• Forestry • Erosion, wetland loss		Medium	High

Farmers | Subsistence farmers | Food-stressed populations | Rural populations | Indigenous populations | Rural population with poor energy access

	ACTION SET	VULNERABILITIES	MOST VULNERABLE POPULATIONS	EFFECTIVENESS RATING	EVIDENCE RATING
11	COMMUNITY FORESTRY	• Forestry • Deforestation		High	Medium
12	IMPROVED CROP MANAGEMENT	• Agriculture • Declines in projected yields • Length of growing season		High	Medium
13	DESALINATION	• Salination • Water scarcity		Medium	Very High
14	SALT-TOLERANT CROPS	• Agriculture • Salination		Medium	Very High
15	ENERGY-EFFICIENT BIOMASS STOVES	• Forestry • Deforestation • Cardiovascular, Respiratory diseases		High	High
16	WEATHER STATIONS	• Agriculture • Less predictable weather patterns		High	Medium
17	AQUACULTURE DIVERSIFICATION	• Fisheries		Medium	Medium
18	SHELLFISH BREEDING PROGRAMMES	• Fisheries		Medium	Medium
19	CORAL RESTORATION	• Damage to marine ecosystems • Tourism income • Fisheries		Medium	Medium

Very low Low Medium High Very high

DRIP IRRIGATION

1

To reduce pressure on fresh water resources by dripping water slowly to the roots of plants through a network of valves, pipes, tubing and emitters.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	Typically within 1 year
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $100,000-$500,000

Impacts Addressed: **Agriculture, water scarcity**

Drip irrigation programmes rate highly on cost-effectiveness, co-benefits, and scalability.

With a cost-benefit ratio of zero, and implementation achievable within one year, the programme is cost-effective. The primary co-benefit of the programme is food security. In Senegal, the programme is also expected to increase rural inhabitants' quality of living and reduce energy consumption.

Implementation concerns for a programme in Mauritania include maintenance and a potential lack of water to feed the system. Coordination among multiple players and sectors was also noted as vital to the programme's success.

Peer-reviewed studies are currently available through the World Bank, UNFCCC and UNEP. Recognition of the programme by policy makers is already relatively high.

MDG BOOST ↑1, ↑7

Sources: ECA WORKING GROUP (2009), NAPA, Mauritania (2008), NAPA, Senegal (2008), NAPA, Cape Verde (2008)

SOIL CONSERVATION

2

Reduce soil erosion by identifying and implementing soil conservation techniques, such as reduced tillage and mulching.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 1 year
SCALABILITY	Medium				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 3 years

Expense: $2 million +

Impacts Addressed: **Drought, water scarcity**

Soil conservation programmes rate highly on cost-effectiveness and co-benefits. In Maharashtra, India, the programme was found to have a cost-benefit ratio of -0.2. Because soil conservation techniques involve less use of fertilizer and tillers, it can yield large cost savings. Implementation can occur within three years. Co-benefits include increased food security and improved water quality from a reduced sediment load in coastal waters.

Barriers to implementation include a possible lack of participation and interest from farmers and a lack of consistent implementation, since all farms in each programme area must participate to ensure its success.

The programme is relevant in all areas subject to loss of forest cover and inappropriate land use. Presently, technical guidelines and training programmes are limited.

MDG BOOST ↑1, ↑7

Sources: ECA WORKING GROUP (2009), NAPA, Cambodia (2008)

CROP ENGINEERING FOR DROUGHT RESISTANCE

3

Seed-engineering measures to make plants more drought-tolerant through conventional breeding.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	Typically within 1 year
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $5 million – $100 million +

Impacts Addressed: **Agriculture, water scarcity**

Programmes that promote crop engineering for drought resistance rate highly on cost-effectiveness, co-benefits and scalability. The cost-benefit ratio of the programme is 0.1 for irrigated agriculture and 0.7 for rain-fed agriculture. Implementation is possible within one year, although the full effects are more long-term.

The programme targets all groups, regardless of income. The main co-benefit is improved food security. In Burundi, varieties of sweet potato, sorghum, and corn are being developed to resist drought and adapt to the weak soil fertility in affected regions.

The programme is relevant to countries with a high reliance on food production from natural resources. Specifications and guidelines are available through local NGOs working in connection with the programme. Training of farmers occurs as a component of NAPA implementation.

The World Bank, UNFCCC, and UNEP have conducted peer-reviewed studies on this programme, but it could benefit from further quantitative analysis and more case examples.

MDG BOOST ↑1, ↑7

Sources: NAPA, Bangladesh (2005), NAPA, Burundi (2007), NAPA, Cape Verde (2007), UNDP/NAPA, Bangladesh (2005), ECA Working Group (2009)

DRAINAGE SYSTEMS

4

Development of irrigation and drainage systems for agricultural production.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 1 year
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5-10 years

Expense: $74 (Irrigated) - $80 million (Rain-fed)

Impacts Addressed: **Agriculture, water scarcity**

Drainage system upgrade programmes rate highly on cost-effectiveness, co-benefits, and scalability. Although initial costs are high, the programme has a cost-benefit ratio of -2.1 (rain-fed) to -0.2 (irrigated). Implementation is possible within a year.

Co-benefits include improved food security and water conservation. In Sierra Leone, the long-term results of such a programme include increased income among farmers, poverty alleviation, and improved food storage, processing, and marketing.

The programme's feasibility is dependent on the availability of well-trained technicians and farmers; monitoring and supervision; and the availability of essential equipment and tools. Risks and barriers include the availability of funding, a potential increase in waterborne diseases, and poor production infrastructure.

The World Bank, UNFCCC, and UNEP have carried out peer-reviewed studies on this programme.

MDG BOOST ↑1, ↑7

Sources: Sources: NAPA, Sierra Leone (2008), ECA Working Group (2009), IFPRI (2009)

RAIN WATER HARVESTING

5

Supplementing domestic/household water requirements by collecting, treating, and storing rainwater as part of a wider drinking water supply programme.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✓	Implementation Lapse	Typically within 1 year
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 4 years

Expense: $500,000 +

Impacts Addressed: **Agriculture, water scarcity**

Rainwater harvesting programmes rate highly on cost-effectiveness, co-benefits, and scalability. The programme has a cost-benefit ratio of 0.1. A simple and affordable rainwater harvesting system combined with an integrated approach to agricultural production significantly improves the lives of local farmers. A rainwater harvesting programme in Burundi reported such benefits as an increase in farmer income, and improved food security and health due to safe drinking water. Rainwater harvesting may also help control erosion and flooding during periods of excessive rainfall.

The programme is highly relevant in low-income countries. Various rainwater harvesting technologies have been adopted successfully in many parts of the world. Programme guidelines are available through local and global NGOs, and training programmes are included as part of the implementation process.

Implementation risks include labour shortage and a lack of farmer participation. In extreme dry seasons, rainwater harvesting may fail.

Peer-reviewed studies are available through UNFCCC and UNEP. The programme would profit from greater recognition at the policy-making level and additional quantitative assessment.

MDG BOOST ↑1, ↑4, ↑5, ↑6, ↑7

Sources: ECA Working Group (2009), NAPA, Burundi (2008), NAPA, Bhutan (2006)

WATER STORAGE FACILITIES

6

Building water storage facilities for household and emergency use.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✓
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically within 2 years
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 4 years

Expense: $200,000 +

Impacts Addressed: **Agriculture, water scarcity**

Water storage facility programmes rate highly across all assessment categories. Implementation is possible within two years. Co-benefits include improvements to agriculture and livestock, better human health, and improved water quality. Potential barriers to implementation include insufficient space to build a water storage structure, social resistance to water conservation techniques, and inadequate financing. Since the programme is dependent on rainwater, it will serve little purpose in areas of low rainfall. Projects have been successful on some islands in Tuvalu but have failed on others.

Training programmes are accessible through UNDP Global Environment Facility's Small Grants Programme International Waters Resource Guide. Peer-reviewed studies are available through UNFCCC and UNEP, but the programme would profit from greater recognition at the policy-making level and from additional quantitative assessment.

MDG BOOST ↑1, ↑4, ↑5, ↑6, ↑7

Sources: ECA Working Group (2009), NAPA, Samoa (2008) , NAPA, Tuvalu (2007), GEF (2010), GEF SGP Mauritius (2001), de Fraiture & Molden (2010)

CANAL LINING

7

Lining canals to reduce water losses, since water losses in unlined irrigation canals can be high.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✓
CO-BENEFITS	Very High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically within 2-4 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $5 million - $10 million

Impacts Addressed: **Agriculture, water scarcity**

Canal lining programmes rate highly on co-benefits, feasibility, and scalability.

The project leads to increased food crops, which leads to increased household income. It is also beneficial to women and children, as it reduces the time and effort needed to search for water. In Tanzania, a rehabilitated irrigation canal and water reservoir increased food crops and introduced a new cash crop. Sales of the surplus provided families with income, reducing poverty and unemployment.

Potential project hurdles include a lack of local engagement and participation, and a lack of external funding. Extreme weather conditions may also affect implementation.

Guidelines, technical assistance, and training are usually incorporated as part of the overall programme. Studies have been carried out as part of UNFCCC and UNDP projects, but the programme could benefit from further cost-benefit analysis and greater attention at the policy-making level.

MDG BOOST ↑1

Sources: ECA Working Group (2009), GEF (2004), NAPA, Cambodia (2006), de Fraiture & Molden (2010)

INTEGRATED PEST MANAGEMENT (IPM)

8

Understanding how climate change affects pest outbreaks. Such a programme can result in more cost-effective pest management and is sensitive to the effects on vulnerable communities and women.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✓
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 3-5 years
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $5 million +

Impacts Addressed: **Pests, drought**

Integrated pest management programmes rate highly on cost-effectiveness, co-benefits, and scalability. Analyses have shown a 0.1 cost-benefit ratio for the programme in India.

Protecting crops from pests results in higher agricultural output. Long-term results for a programme in Uganda include decreased pest outbreaks, ecological shifts of vector-borne and communicable diseases and pests, improved human health, and sustained socio-economic development.

The programme is especially relevant in low-income countries, where natural resources are a main income source. The programme provides training and tests various pest-management technologies as part of the implementation process. Feasibility challenges may include inadequate funding and insufficient community mobilization and response. Natural hazards, disasters, and civil conflicts will also impede the programme's success.

The programme can result in improved food security, better human and animal health, and a reduction in diseases such as malaria. Recognition of the programme is increasing at the policy-making level, but it would benefit from additional research.

MDG BOOST ↑1, ↑4, ↑5, ↑6, ↑7

Sources: ECA Working Group (2009), NAPA, Uganda (2008)

GROUNDWATER MANAGEMENT

9

To improve the operation and use of underground water in order to protect its quality and optimize water supply.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Very High	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 3 years
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 3 years

Expense: $100,000 +

Impacts Addressed: **Agriculture, drought**

Groundwater management programmes rate highly on cost-effectiveness, co-benefits, and scalability. Analyses show a 0.7 cost-benefit ratio for the programme, with implementation possible within three years. In Mauritania, the co-benefits of a groundwater management improvement programme include more effective cultivation methods, higher agricultural productivity, and improved water quality.

Technical specifications and guidelines for the programme are available through local and global NGOs. Where implemented, local training is included as a component of NAPA projects.

Potential programme difficulties include conflicts between governing agencies over areas of jurisdiction, training of technicians, and obtaining equipment such as pumps. Water sources are also sensitive to pollution and harmful effects.

Peer-reviewed studies are available through UNFCCC programmes. The programme also complements water, sanitation, and energy sector reform.

MDG BOOST ↑1, ↑4, ↑5, ↑6, ↑7

Sources: ECA Working Group (2009), NAPA, Mauritania (2004) , NAPA, Niger (2006), de Fraiture & Molden (2010)

MANGROVE RESTORATION AND PROTECTION

10

In addition to building up land and protecting shorelines, mangroves serve as a habitat for many fish and wildlife species. The main techniques for restoring and protecting mangroves include 'planting alone', hydrologic restoration, and excavation or fill.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 3 years
SCALABILITY	Very High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $250,000 - $1 million

Impacts Addressed: **Forestry, fisheries, and coastal protection**

Mangrove restoration and protection programmes rate highly on co-benefits and scalability. Rehabilitated mangrove forests provide coastal protection and can also improve economic production. In the Gulf of Thailand, fishing, environmental benefits, and flood proofing were cited as programme advantages.

The programme is highly relevant, since many low-income nations have lost high percentages of mangrove coverage. UNESCO and university programmes have developed many guidelines and specifications for techniques and training in mangrove restoration.

In the Gulf of Thailand, the restoration of 1,200 hectares of mangrove forest resulted in an estimated $100,000 economic gain to fisheries. Costs of restoration would be recovered in 2.4 - 8.4 years. The price of restoration per hectare can fluctuate significantly, depending on the method of restoration.

Programme success can vary widely depending on the environment and the techniques used. If the method of restoration is self-repairing, the project depends on the presence of waterborne seeds or seedlings from adjacent mangrove stands. Restoration also requires that normal tidal hydrology is not disrupted, further complicating implementation. Although there is already a high level of recognition for the programme at the policy-making level, the programme's success also depends on being able to raise public awareness of the value of mangroves.

MDG BOOST ↑1, ↑7

Sources: ECA Working Group (2009), NAPA, Mauritania (2004) NAPA, Cambodia (2007), Lewis III (2001)

COMMUNITY FORESTRY

11

Tree and mangrove planting to prevent deforestation and promote agroforestry.

ASSESSMENT Very High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically within 3 years
SCALABILITY	Very High				
EVIDENCE BASE	Very High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $5 million +

Impacts Addressed: **Deforestation**

Community forestry programmes rate highly in all areas. The cost-benefit ratio has been estimated to be between 0 and 1 for medium-income households. A community reforestation project in Tanzania aims to improve the livelihood of communities around Mount Kilimanjaro by providing alternative sources of income and food through replanting of trees and economic diversification.

Implementation risks include natural hazards and pests, insufficient funding, and civil conflicts. Forest plantations in arid and semi-arid zones may have little beneficial effects unless they are closely related to the needs and priorities of local inhabitants.

So it is important to integrate forestation into farming systems not only for the purpose of growing trees but also to improve the welfare of rural families.

Programme guidelines and training are available through UNCCD's globally launched Thematic Programme Networks (TPNs) and the "Mediterranean Forest Action Programme" (MED-FAP).

MDG BOOST ↑1, ↑7

Sources: UNCCD (2004), Dahal (2006), Waithaka et al. (2010)

IMPROVED CROP MANAGEMENT

12

Changes to crop-planting dates to maximize yield under new climatic conditions; can be combined with changes to fertilizer and irrigation.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✓	Quick Start	✓
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✓	Implementation Lapse	Typically within 0.5 years
SCALABILITY	Medium				
EVIDENCE BASE	Medium	Long-Term	✗	Programme Cycle	Typically 2-3 years

Expense: Unknown

Impacts Addressed: **Drought and/or excess rainfall**

Programmes for improving crop management rate highly in cost-effectiveness, co-benefits and feasibility. Though there is no clear determination of the programme's cost-effectiveness, in theory, planting dates can be changed without any extra cost, and such a programme can be implemented within a harvesting season.

Co-benefits include increased food security. If the new planting schedule is adopted on the regional or national scale, the programme may also assist in preventing food shortages. Poor subsistence farmers are the main beneficiaries of this programme, although it is relevant to all groups.

A drought-adaptation programme in Uganda that shifts planting seasons to maximize on shortened seasonal rains will also result in better quality of food consumed, leading to improved nutrition. And an increase in crops to sell raises the household income.

Access to weather data and research in drought-resistant crop varieties is necessary for successful implementation. Shifting weather patterns and quality of weather data are also factors to consider. Programme results may vary depending on regions and crops.

The programme is highly relevant in low-income countries, especially since it is low-cost and effective. Although overall guidelines for the programme exist, it should be implemented case-by-case based on geographical location and crop type.

MDG BOOST ↑1, ↑7

Sources: IPCC (2007), Easterling et al. (2007)

DESALINATION

13

Seawater desalination is a well-established process, mainly for drinking-water supply, in water scarce regions.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 1 year
SCALABILITY	Very High				
EVIDENCE BASE	Very High	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $0.50 - $1.50/$m^3$ water

Impacts Addressed: **Water scarcity**

Desalinisation programmes rate highly in co-benefits and scalability. The programme benefits populations in water scarce areas as well as the agricultural sector. If conducted well, the programme can also result in environmental benefits to coastal sites. In Mauritius, a project developed locally-constructed solar water desali¬nation units and installed them in the remote community. Livelihood benefits include improved health and a reduced burden on women, who previously had to walk 3-5 hours per day to find drinking water.

There are many well-documented case examples, and the programme is highly relevant for all arid and drought prone/water scarce zones. Renewable energy is increasingly being used as an energy source in community-based projects.

If scaled up, this technology could offer an option for non-fossil fuel dependent water access.

The cost-benefit ratio of the programme depends on the technique used. The costs are still too high for full use of such a programme in irrigated agriculture compared to other methods such as wastewater treatment. But used for drinking water it has proved its cost-effectiveness.

Project success is highly variable. The programme normally requires long-distance transport of desalinated water to its site of use. Fluctuating energy prices are also a risk factor, as energy costs for running a desalination plant account for up to half of the programme cost.

MDG BOOST ↑1, ↑3, ↑4, ↑5, ↑6, ↑7

Sources: Ghaffer (2006), UN (2009), GEF/UNDP (1997), Beltrán & Koo-Oshima (2004)

SALT-TOLERANT CROPS

14

Growing salt-tolerant crops on land irrigated with water pumped from the ocean.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	Very High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 1 year
SCALABILITY	Very High				
EVIDENCE BASE	Very High	Long-Term	✓	Programme Cycle	Typically 3 years

Expense: $606 per acre, on average

Impacts Addressed: **Food insecurity, water scarcity**

Salt-tolerant crops programmes rate highly in co-benefits and scalability. The programme benefits populations in arid, drought-prone, coastal nations.

Salt-tolerant crops are currently used to feed livestock. It also has potential for use in producing bio-friendly fuels. Two requirements must be met if salt-tolerant crops are to be cost-effective. First, they must produce yields high enough to justify the expense of pumping irrigation water from the sea. Second, researchers must develop agronomic techniques for growing seawater-irrigated crops in a sustainable manner.

Halophytes (plants that naturally grow in saline environments) have been singled out as the most suitable salt-tolerant crop. Research has been conducted in salt-tolerant crops for agricultural purposes but is not yet able to match the same production scale as crops intended for livestock.

MDG BOOST ↑1, ↑7

Sources: UN (2009), Hendricks & Bushnell (2009), Glenn, Brown & O'Leary (1998), Beltrán & Koo-Oshima (2004), GEF/UNDP (1997)

ENERGY EFFICIENT BIOMASS STOVES

15

Substituting traditional stoves (such as three-stone cooking fires) with more efficient chimney-fitted stoves to save energy and time.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	Medium				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically within 2 years
SCALABILITY	High				
EVIDENCE BASE	High	Long-Term	✓	Programme Cycle	Typically 3 years

Expense: $200,000

Impacts Addressed: **Deforestation, respiratory illness**

Energy-efficient biomass stove programmes rate highly on cost-effectiveness, feasibility and scalability. Although no cost-benefit ratio has been determined, the programme can be fully implemented within two years.

Successful implementation depends on community awareness and willingness to adopt new cooking and heating methods. The programme is highly relevant in low-income countries, where significant populations have limited access to energy. Guidelines and training programmes are available through NAPA projects and the World Bank. The World Bank's "Fuel Source Module" also contains training resources for the programme.

The programme is projected to have a large impact on human health, biodiversity, and quality of life. Lower-income households benefit the most, since they rely more on traditional fuels than higher-income households do.

MDG BOOST ↑1, ↑4, ↑5, ↑7

Sources: NAPA, Burundi (2008), Barnes et al. (2004)

WEATHER STATIONS

16

The application of meteorology to agriculture is essential, since every facet of agricultural activity depends on the weather.

ASSESSMENT High

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	High	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Very High	Short-Term	✗	Implementation Lapse	Typically within 1 year
SCALABILITY	Very High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 3 years

Expense: $500,000 +

Impacts Addressed: **Food insecurity, agriculture**

Weather station programmes rate well on all assessment levels. They are cost-effective in agriculture when applied correctly and use automatic solutions.

If automatic weather stations are used, costs are consistent. The programme can be implemented within a short timeframe, but its full effects are more long-term, since an automated system requires weather data collected over time. In Bhutan, where even slight changes in monsoon patterns can result in significant changes in agricultural productivity, co-benefits include higher agricultural productivity, better food security, improved living standards, and sustainable use of natural resources.

Risks are low if the technical capability is on hand to set up the stations. Dissemination and distribution of weather data is key. If automated, standard, weather stations are used, then sensitivity to external factors is very low. However, there are key gaps in the understanding of and ability to predict the global climate system. The deteriorating state of the climate observing system in Africa, for example, presents an impediment to understanding climate effectively.

Technical guidelines and training programmes are available through the World Meteorological Organization.

MDG BOOST ↑1, ↑7

Sources: NAPA, Bhutan (2008), Stefanski et al. (2007), Plummer et al. (2003), WMO

AQUACULTURE DIVERSIFICATION

17

Establishment of marine protected areas, restoration efforts targeting the health of corals and fish, and stock enhancement to maintain a vigorous coral reef.

ASSESSMENT Medium

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 3 years
SCALABILITY	Medium				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 4 years

Expense: $500,000 - $1 million

Impacts Addressed: **Loss of marine fish stocks**

Acquaculture diversification programmes have substantial co-benefits: They improve food security, future biodiversity, and fish stocks. In Vanuatu, a community-based marine management programme aims to use national fisheries to support economic growth, create jobs, and enable sustainable development.

The programme's cost-effectiveness is unclear. Implementation may be hindered by a lack of funding and conflicting policy interests (such as fear of decreasing tourism due to restricted area access). The programme requires an awareness and understanding of local communities.

The programme is highly relevant to low-income countries due to their large dependence on natural resources. Unfortunately, few guidelines and training programmes are available. The effects of global warming on fisheries are currently not well understood but are beginning to receive attention.

MDG BOOST ↑1, ↑7

Sources: NAPA, Vanatu (2007), NAPA, The Gambia (2007), FAO (2010)

SHELLFISH BREEDING

18

Shifting vulnerable populations of shellfish to suitable sites and using marine or onshore breeding programmes will result in the natural breeding of shellfish and regeneration of the shellfish population.

ASSESSMENT Medium

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	Medium	Short-Term	✗	Implementation Lapse	Typically within 3 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $250,000 +

Impacts Addressed: **Loss of marine fish stocks, sea temperature rise**

Shellfish breeding programmes have significant co-benefits and are easy to scale-up. In Tuvalu, coral reef resources are the most easily accessible and main protein source of food for low-income and subsistence families on all islands of Tuvalu. The programme will enhance coral reef fishery biodiversity and improve socio-economic conditions in the related communities.

Guidelines from various local NGOs exist. Training programmes are primarily locally based in connection with a larger project.

The programme is estimated to be relatively high-cost, but no comprehensive evaluation has been made yet. Cost-effectiveness will most likely determine what type of breeding practice is adopted.

Community cooperation and funding availability are vital components of the programme. The programme requires an awareness and understanding of the local community.

MDG BOOST ↑1, ↑7

Sources: NAPA, Tuvalu (2007), FAO (2010)

CORAL RESTORATION

19

Monitor, restore, and enhance coral reefs to prevent coral bleaching; establish marine protected areas.

ASSESSMENT Medium

		EFFECT		IMPLEMENTATION TIMEFRAME	
COST-EFFECTIVENESS	Medium	Immediate	✗	Quick Start	✗
CO-BENEFITS	High				
FEASIBILITY	High	Short-Term	✗	Implementation Lapse	Typically within 3 years
SCALABILITY	High				
EVIDENCE BASE	Medium	Long-Term	✓	Programme Cycle	Typically 5 years

Expense: $500,000 +

Impacts Addressed: **Loss of marine ecosystems, food insecurity**

Coral reef restoration programmes have significant co-benefits and rate highly for feasibility and scalability. The programme increases the breeding of certain fish species, positively impacting biodiversity and food security. In Kiribati, coral reefs are critical to subsistence and artisanal fisheries that are the main life-supporting activities of local communities.

Implementation risks include a lack of funding and awareness and a lack of interest in implementing programmes at the local level. Increased tourism, which puts additional pressure on coral reef ecosystems, also poses a major risk to established programmes.

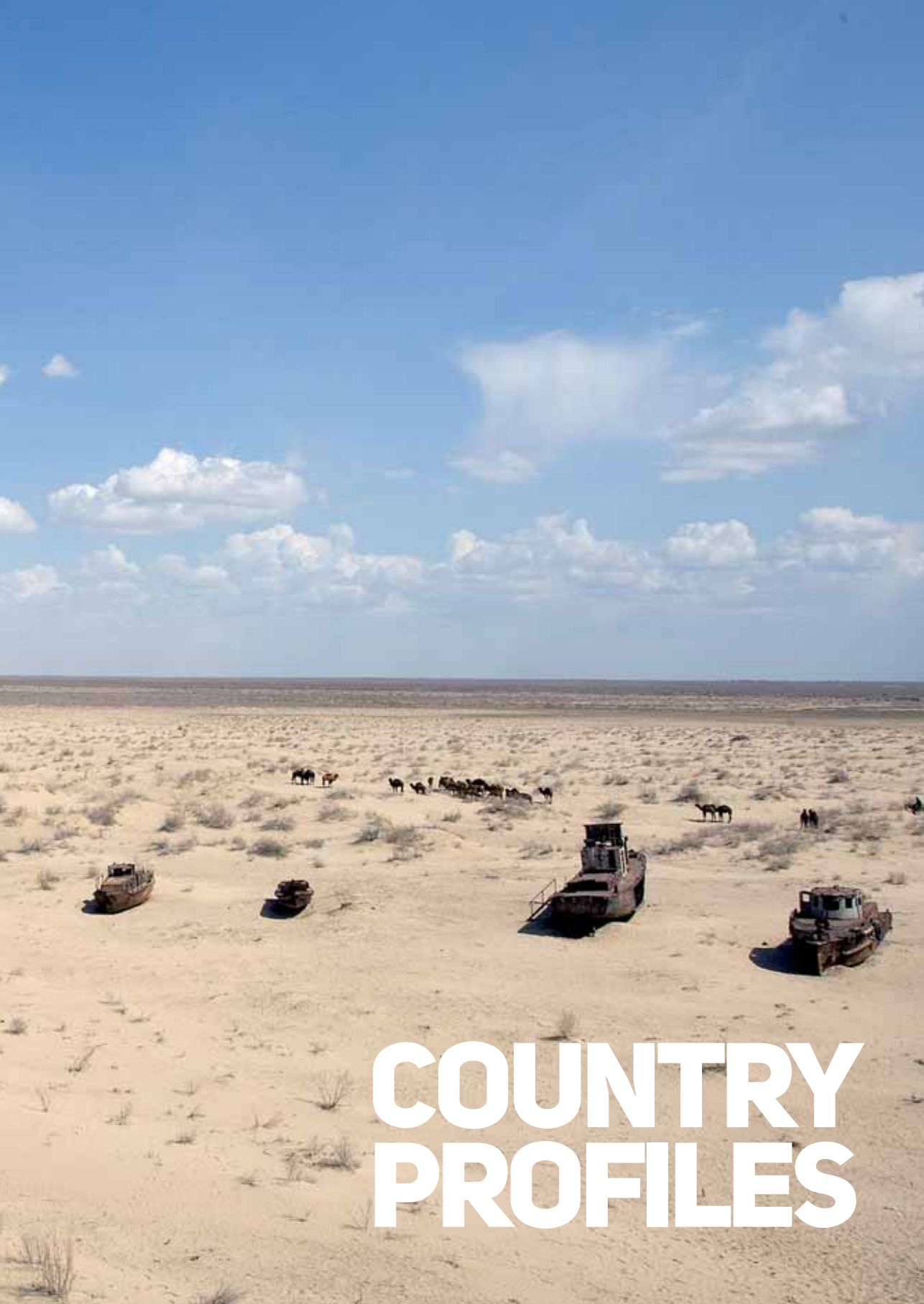
Programme guidelines are locally and globally available. Local NGOs are involved in training for project implementation. The programme could benefit from additional peer-reviewed study and assessment.

MDG BOOST ↑1, ↑7

Sources: NAPA, Kiribati (2007) , UNFCCC (2009), FAO (2010)

Redeveloping community in the Maldives. Source: IFRC.

A view of rusted, abandoned ships in Muynak, Uzbekistan, a former port city whose population has dropped with the rapid recession of the Aral Sea. Source: UN Photo/Eskinder Debebe.



COUNTRY PROFILES

COUNTRY PROFILES

Country Profiles are included here of four nations affected in very different ways by the impacts of climate change. Each Country Profile gives a closer look at what the various other sections of this report imply in a given country situation. In particular, they provide a basic snapshot of how the impacts expressed in the Climate Vulnerability Monitor play out at a country level.

The group was selected so that overall they would cover a wide range of different national characteristics and climate stresses, providing a good yardstick against which some of the conclusions of this report can be evaluated at a country level. They vary in geographic, demographic and socioeconomic terms and cover each of the main regions.

In particular, one Profile was chosen with respect to each of the main different types of hallmark stresses examined in the report: Dominican Republic (Weather Disasters), Maldives (Habitat Loss and Economic Stress) and Mozambique (Multiple Stresses, including Health Impact). A further Profile (Denmark) focuses on a country with very low vulnerability to climate change. The vulnerabilities of each are evolving in different ways, some faster than others: The Dominican Republic is High (2010)/ High (2030), the Madives is Severe (2010) / Acute (2030), and Mozambique is Acute (2010) / Acute (2030). Denmark's vulnerability (Low / Low) will decrease further still.

The Maldives and Mozambique suffer multiple stresses, with Maldives most vulnerable to the economic and sea-level rise impacts of climate change, and Mozambique highly vulnerable to desertification, agricultural and water impacts, as well as health problems. The Dominican Republic is most vulnerable to extreme weather.

In terms of human development, Denmark ranks 19th or "very high" according to the UN Human Development Index (HDI). The Dominican Republic is assessed as having "medium" development. Maldives was until recently classified as one of approximately 50 least developed countries, while Mozambique has among the lowest levels of human development on the planet according to the UN Development Programme (UNDP).

Each Profile provides national-level information as implied by the Climate Vulnerability Monitor, a list of documented climate impacts and a set of possible remedial actions for reducing vulnerabilities as outlined in the Adaptation Performance Review of this report. Profiles also include basic socio-economic, demographic and geographic indicators highlighting some key differences between each country examined.

The information compiled relies on statistical data from central intergovernmental and government sources, submissions to the UN Framework Convention on Climate Change (UNFCCC), adaptation programmes and other expert reference sources cited or mentioned in the Bibliography.

Flood waters rage through a broken dyke at Makunda in Busian, Western Kenya. Source: Edward Kale/IRIN.

DENMARK

LOW

KEY FIGURES

POPULATION	**5,526,000**
ECONOMY	
2010 GDP PPP (US DOLLARS)	
TOTAL	$203.2 billion
PER CAPITA	$36,336
REAL GROWTH	1.20%
GDP BY SECTOR	
PRIMARY/EXTRACTIVE	1.2%
SECONDARY/PRODUCTIVE	23.8%
TERTIARY/SERVICES	74.9%
KEY INDUSTRIES	Oil and gas, Clean Energy Technologies, Pharmaceuticals, Information Technology, Shipping Equipment, Business Services, Research and Development

SOCIO-ECONOMIC DEVELOPMENT

HUMAN DEVELOPMENT (RANK)	Very High (19th)
LIFE EXPECTANCY	78.2 years
ANNUAL POPULATION GROWTH	0.10%
ILLITERACY	1%
URBAN POPULATION	85%
ACCESS TO ELECTRICITY	100%
GENDER DEVELOPMENT	12th
UNDERNOURISHED POPULATION (2002/04)	<2.5%
LIVING BELOW POVERTY LINE ($2/DAY)	No data
POPULATION WITHOUT IMPROVED WATER SOURCE	No data
OFFICIAL DEVELOPMENT ASSISTANCE (2008)	$2.8 billion (disbursed)
PUBLIC HEALTH EXPENDITURE	8%
PUBLIC EDUCATION EXPENDITURE	7%

With its relatively small population of 5.4 million and a total area of 43,000 square km, Denmark is the smallest country in Scandinavia, comprised by the northward-thrusting peninsula of Jutland and 443 named islands. The climate in Denmark is temperate with precipitation evenly distributed over the year and mean annual temperatures of 7.7° Celsius (45.9° Fahrenheit).[287] More than 66% of the country area is used for agriculture, 11% is forested, and 10% is towns, roads, and scattered housing. The rest is natural areas, such as lakes and watercourses.[288]

In relation to the impacts of climate change, Denmark is a robust country. Legislation prevents building in river valleys, along the coast, and in the forests. Agricultural land is well drained, and in dry periods, farmers can access various irrigation methods. Weather disasters are rare and carry extremely low casualties. Systematic warning systems function well and almost all damage losses would be covered by insurance. Nevertheless, since Denmark has registered multiple billion dollar storms during the last 20 years, it registers a factor of Moderate for Weather Disasters, which may overstate the situation. Finally, the Danish public health sector provides medical care of high standards to all income groups, and water sanitation levels are high.[289] Thus, the vulnerability trends observed in Denmark as a result of climate change differ significantly from other case countries in this report. In several areas, the impacts of climate change are considered to result in economic gains rather than losses.

The economic stress Monitor shows a near positive climate change impact in Denmark 2010, and a clear positive impact by 2030. The positive effect is related to the fisheries sector, since catch potential is expected to increase due to the warming effect of the oceans. Statistics from DMI (the Danish Meteorological Institute) show that the mean temperature in Denmark is approaching 8.5°C (47.3° F); an increase of almost 1.5° C (2.7° F) since the end of the 19th century.[290] Following a recent study, rising temperatures lead to large-scale redistribution of catch potential with an average 30-70% increase in high-latitude regions.[291] Excessive algae blooms including toxic effects for fish and other aquaculture especially in the Baltic Sea, may limit some of that possible improvement in fish catch. Furthermore, rising temperatures are also expected to have positive impacts on agricultural production, since CO_2 concentrations will

CLIMATE/GEOGRAPHY

CLIMATE ZONE	Temperate
PROJECTED RAINFALL CHANGE	Increase
TROPICAL CYCLONES	No
DESERTIFICATION	None
LAND AREA IN LOW-ELEVATION COASTAL ZONE (LECZ) (10M/33 FT AND BELOW)	26%
FOREST COVER ANNUAL CHANGE	+0.8%

MIGRATION/DISPLACEMENT

EMIGRATION RATE	4.30%
IMMIGRANTS AS SHARE OF TOTAL POPULATION	7.80%
INTERNALLY DISPLACED PEOPLE	None

DISASTER HISTORY

TYPE	YEAR	KILLED	NUMBER OF PEOPLE AFFECTED	DAMAGE
STORM	1990			120 million
STORM	1990			60 million
STORM	1990	1		10 million
STORM	1999	7		2.6 billion
STORM	2005	4		1,3 billion
STORM	2007			100 million

increase as well.[292] High CO_2 reduces the stomatal openings of some crop plants, which reduces transpiration per unit leaf area while enhancing photosynthesis. This may lead to improved water-use efficiency, and this increases the growth and yield of most agricultural plants,[293] although high concentrations of ground-level ozone gas and accelerated weed growth may prevent the full realization of these benefits.

Rising temperatures together with a reduction in summer precipitation in the order of 10-25% might also affect the need for irrigation in rural and agricultural areas, as well as the already increasing need in urban areas for cooling and watering of green areas.[294] Following UNFCCC estimates from 2003, this could exacerbate the already existing problems of over-use of groundwater resources in Denmark.[295]

The vulnerability trends related to sea-level rise is moderate in Denmark. This implies some additional stress and opportunity cost spending in the economy on maintaining and repairing existing coastal infrastructure, so no special actions would normally be required to be taken to counteract the few centimetres of higher water expected in the next two decades. The actual risk of habitat loss due to sea-level rise is almost non-existent in the foreseeable future. Longer-term however, if the 21st century were to bring nearly 1 meter (3 ft) of sea-level rise, Denmark would feel a much stronger impact with nearly one quarter of its population in the low-elevation coastal zone at or below 10 metres (30 ft) above sea-level. The economic consequences of sea-level rise are calculated to amount to less than 0.25% of GDP in 2010, and the trend for 2030 indicates only a very small increase in this figure.

However, even though sea-level rise is not estimated to burden the Danish economy, there are special and complex problems linked to low-lying areas exposed to both increases in sea-level rise and increasing drainage from the land. There is a potential risk for loss of coastal areas or loss of agricultural land, since about 80% of the country's population inhabits urban areas closely connected to the coast, and around 1800 km of coastline is protected by dikes or other fixed installations.[296] Over the past 115 years, the sea-level around Denmark has risen steadily, recording water levels rising by 1mm per year measured on the ground.[297]

Finally, it is worth noting that even though the impacts and direct effects of climate change in Denmark are considered low, the indirect effects of climate change impacts in countries outside but close to Denmark are not taken into consideration, since these have not yet been uncovered.[298] Thus, the process and research required to uncover these indirect effects play a key part in future adaptation methods and assessments.

CLIMATE VULNERABILITY INDICATORS

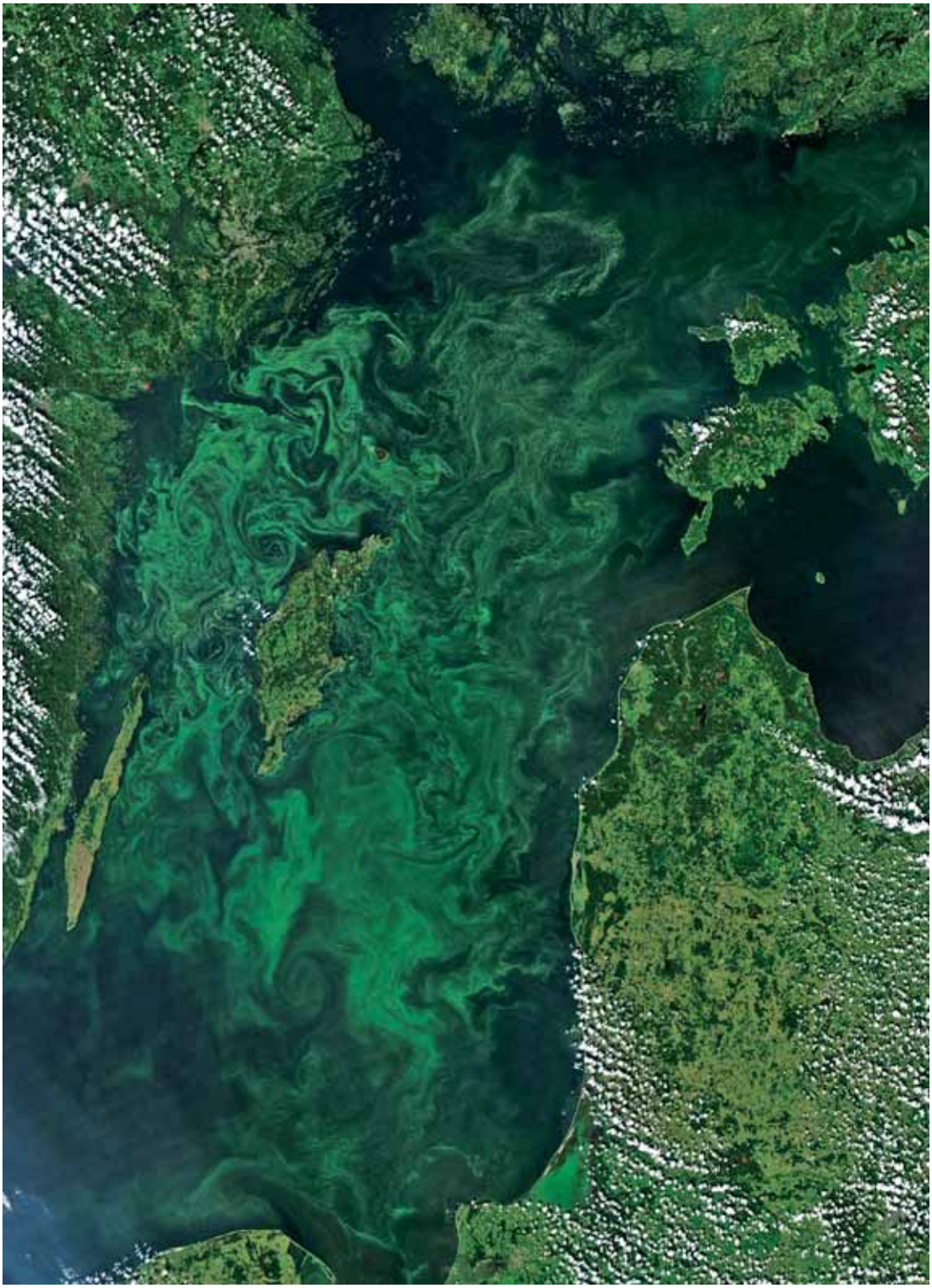
	2010	TREND	2030	
AGGREGATE VULNERABILITY	●	↘	●	
HEALTH IMPACT	●	↓	●	
	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY
MALNUTRITION	Nil	Nil	Nil	Nil
DIARRHEA	Nil	Nil	Nil	Nil
MALARIA	Nil	Nil	Nil	Nil
CARDIOVASCULAR	Nil	Nil	-0.4	N/A
RESPIRATORY	Nil	Nil	-0.1	N/A
DENGUE	Nil	Nil	Nil	Nil
TOTAL				
WEATHER DISASTERS	●	→	●	
	DAMAGE	MORTALITY	DAMAGE	MORTALITY
FLOODS		Nil		Nil
STORMS & WILDFIRES		Nil		Nil
TOTAL WEATHER DISASTERS	$14 million		$36 million	
HABITAT LOSS	●	→	●	
	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK
DESERTIFICATION	Nil	Nil	Nil	Nil
	COSTS AS SHARE OF GDP	TOTAL COSTS	COSTS AS SHARE OF GDP	TOTAL COSTS
SEA-LEVEL RISE	0.21%	$430 million	0.28%	$737 million
ECONOMIC STRESS	●	↓	●	
	IMPACT AS SHARE OF GDP	TOTAL IMPACT	IMPACT AS SHARE OF GDP	TOTAL IMPACT
LAND	-0.065%	-$132 million	-0.09%	-$237 million
MARINE	0.04%	$82 million	0.21%	$553 million
TOTAL	-0.023%	-$50 million	0.12%	$316 million

Nil = close to zero

All Figures are Annual expressed in either 2010 or for 2030. All numbers are purely estimative. The absolute economic figures are expressed as the relative impact (%) times current (IMF, 2009) USD PPP corrected GDP. 2030 absolute economic figures have, for illustrative purposes been corrected for expected future real GDP growth (the relative difference between FUND scenario 2010 and 2030).

Sources: IMF, CIA Factbook, UNDP, OECD Factbook 201, UNFCCC, NAPA/IPCC, CESIN.

⊕ Acute+ ● Acute ⊖ Acute- ⊕ Severe+ ● Severe ⊖ Severe- ⊕ High+ ● High ⊖ High- ● Moderate ● Low ↑ Increasing → Stable ↓ Decreasing



Large-scale algae blooms in the Baltic Sea, Summer 2005. Source: Jeff Schmaltz/NASA.

DOMINICAN REPUBLIC

HIGH

KEY FIGURES

POPULATION	**9,161,000**
ECONOMY	
2010 GDP PPP (US DOLLARS)	
TOTAL	$83.72 billion
PER CAPITA	$9.139
REAL GROWTH	3.50%
GDP BY SECTOR	
PRIMARY/EXTRACTIVE	11.7%
SECONDARY/PRODUCTIVE	21.6%
TERTIARY/SERVICES	66.6%
KEY INDUSTRIES	Tourism, Sugar Processing, Mining, Textiles, Cement, Tobacco

SOCIO-ECONOMIC DEVELOPMENT

HUMAN DEVELOPMENT (RANK)	Medium (88th)
LIFE EXPECTANCY	72.4 years
ANNUAL POPULATION GROWTH	1.70%
ILLITERACY	11%
URBAN POPULATION	55%
ACCESS TO ELECTRICITY	93
GENDER DEVELOPMENT	74th
UNDERNOURISHED POPULATION (2002/04)	29%
LIVING BELOW POVERTY LINE ($2/DAY)	15.1%
POPULATION WITHOUT IMPROVED WATER SOURCE	5%
OFFICIAL DEVELOPMENT ASSISTANCE (2008)	$153 million
PUBLIC HEALTH EXPENDITURE	10%
PUBLIC EDUCATION EXPENDITURE	17%

The Dominican Republic is located on the eastern two-thirds of the island of Hispaniola, between the Caribbean Sea and the North Atlantic Ocean, east of Haiti. It is located in a tropical maritime climate with little seasonal temperature variation; but with high variation in rainfall. The lowest point (Lake Enriquillo) below sea-level (-46 metres/150 ft) contrasts with the country's highest mountain, Pico Duarte (3175 metres /10,400 ft). The country lies in the centre of the hurricane belt and is subject to severe storms from June to October, as well as occasional flooding and periodic drought. The Dominican economy is the eighth largest in Latin America, and one of the strongest in the Caribbean, but the country still faces important challenges of poverty and income inequalities that worsen some of the negative effects of climate change that it is exposed to.

The Dominican Republic is most vulnerable to extreme weather and has the highest factors of vulnerability to Weather Disasters (Acute-/Acute+). The physical vulnerability of the Dominican Republic is evident, given its clear exposure to hurricanes and intense tropical weather. But unlike other countries in the region also in the path of danger, such as Mexico, the Dominican Republic has registered very high human and economic damage due to floods and storms over the last two decades, including in very recent years. Vulnerability is most likely amplified due to the still significant populations of impoverished communities (around 15%) that lack adequate protection and means to persevere environmental shocks of this kind. Flooding, which is becoming more prevalent and severe with climate change, is a particular cause of concern, and accounts for the majority of climate-related extreme weather damages affecting the Dominican Republic.

Investment in more widespread and robust disaster risk reduction measures and programmes would seem imperative in order to limit further damages. Wider risk transfer via insurance or catastrophe bonds to the private sector would strengthen resilience against major economic damages from increasingly severe weather incidents. While strengthened efforts to tackle prevailing income equalities and poverty would be essential to diffusing systemic social vulnerabilities that expose populations to more danger and climate risk.

Health Impacts (High-/High+) follow as the next most significant climate-related concern facing the Dominican Republic.

CLIMATE/GEOGRAPHY

CLIMATE ZONE	Tropical – Hot, and modified due to elevation
PROJECTED RAINFALL CHANGE	Decrease
TROPICAL CYCLONES	Yes
DESERTIFICATION	None
LOW-ELEVATION COASTAL ZONE (10M/33FT AND BELOW)	5%
FOREST COVER ANNUAL CHANGE	No data

MIGRATION/DISPLACEMENT

EMIGRATION RATE	9.10%
IMMIGRANTS AS SHARE OF TOTAL POPULATION	4.10%
INTERNALLY DISPLACED PEOPLE	None

DISASTER HISTORY

TYPE	YEAR	KILLED	NUMBER OF PEOPLE AFFECTED	DAMAGE
STORM	1998	347	975,595	$2 billion
FLOOD	2003	9	65,000	$43 million
FLOOD	2004	688	10,000	
STORM	2004	11	14,000	$296 million
STORM	2007	129	79,730	$78 million
STORM	2007	33	61,600	$45 million
STORM	2007	1	1,600	$40 million
FLOOD	2009	2	4,565	$44 million
FLOOD	2010	1	25,700	

This is primarily because of its very high prevalence of undernourishment and malnutrition registered in the WHO base data of the Monitor. Recent studies underline a persisting high prevalence of malnutrition.[299] Most models expect less rainfall, more heat, including more frequent hot days and thus likely more droughts.[300] This is happening against the background of already light water stress.[301] Changes in the rainfall patterns could also decrease the volume of drinking water in the basins due to drought, creating supply difficulties for the tourism industry; and saline water intrusion due to a combination of rising sea-levels and decreasing rainfall could imply the loss of water quality in fresh water reservoirs. Of particular concern is the Haina River Basin, which contributes a good share of fresh water to the capital city of Santo Domingo.[302]

Agriculture is expected to suffer in the Dominican Republic as a result of these changes, as yields for rice and maize in particular come under more climate stress.[303] This is the main reason why the Dominican Republic registers similar vulnerabilities to economic stress (High-/High-) as with health. Agriculture accounts for roughly 12% of the economy, and losses are estimated to be around USD 100 million dollars per year with slight growth towards 2030. Impacts on agriculture hit the poorest of the poor worst, particularly in rural areas -- both because of health impacts, due to local food shortages or price hikes, and because of lost income. The Monitor very likely understates the economic vulnerability of the Dominican Republic, however, since a roughly equal amount of the economy relies on tourism, which is threatened by coastal and reef erosion that is not taken into account here. The Monitor has yet to highlight fisheries as a major concern in the short term. However, the Dominican Republic's tropical coral reefs and marine biosystems are extremely vulnerable, especially to longer-term climate changes that could cause mass extinction and destruction of coral species during the 21st century, which would have a clear impact on local fish stocks.

The country's health, water and agricultural impacts would be best tackled in unison since they are so closely interwoven. Malnutrition can be addressed through wider health interventions and feeding programmes among high risk groups, although a more promising longer-term strategy might better aim at improving education and prioritizing economic growth in rural and impoverished areas. Good management of water resources will be crucial and updating crop varietals or employing low-water usage techniques for agriculture would help maintain higher yields for key agricultural products for food or cash crops in the face of growing water and other climate stresses.

Habitat Loss (Low/Low) is registered as the lowest vulnerability for the Dominican Republic. However, the economic costs associated with lost potential in the economy due to sea-level rise is already estimated at 200 million USD and growing, more than for other stresses to the economy registered here. The Monitor expects desertification to be slightly less serious year-on-year, according to the IMAGE model, which has mapped the evolution of the phenomena in the Caribbean region. This may be contrary to some local evidence of desertification, and would be counterintuitive in relation to the predicted increases in heat and water stress already affecting the country.[304]

EFFECTIVE ADAPTATION RESPONSES

FOCUS	IMPACT AREA	ACTION NO.	NAME	EFFECTIVENESS RATING	AVERAGE COST
DISASTER RISK REDUCTION	10	Weather disasters	Flood Control	High	$13,000-900,000
DISASTER RISK REDUCTION	3	Weather disasters	Disaster Management Training Programmes	Very High	$25,000-100,000
DISASTER RISK REDUCTION	1	Weather Disasters	Early Warning Systems	High	$1 million+ per system
DISASTER RISK REDUCTION	6	Weather Disasters	Flood Proofing of Roads	High	$100,000-$200,000 per km of road
MALNUTRITION	1	Health Impact	Child Survival Programme with Nutrition Component	Very High	$2-10 per child
MALNUTRITION	2	Health Impact	School Health and Nutrition Programmes	Very High	$37 per DALY
WATER AND HEAT STRESS/ AGRICULTURE	9	Economic Stress	Groundwater Management	High	$100,000+
WATER AND HEAT STRESS/ AGRICULTURE	12	Economic Stress	Improved Crop Management	High	$5 million+
WATER AND HEAT STRESS/ AGRICULTURE	3	Economic Stress	Crop Engineering for Drought Resistance	High	$5-100 million
WATER AND HEAT STRESS/ AGRICULTURE	2	Economic Stress	Soil Conservation	High	$2 million+
WATER AND HEAT STRESS/ AGRICULTURE	14	Economic Stress	Salt-Tolerant Crops	High	$606 per acre, on average
SEA-LEVEL RISE/DISASTER RISK REDUCTION	12	Habitat Loss	Integrated Coastal Management	High	$1 million+
SEA-LEVEL RISE/DISASTER RISK REDUCTION	7	Habitat Loss	Drainage Systems Upgrade	High	$20-50 million

NATIONAL ADAPTATION PROGRAMME FOR ACTION

DATE	2008
NUMBER OF PRIORITY PROJECTS	4
COMBINED PROJECT COSTS	$9.2 million
PROJECTS APPROVED FOR FUNDING	$2 million
KEY FOCUSES	Disaster Management and Capacity; Education and Capacity Building; Coastal Marine Ecosystems; Management of Water Resources

Very low Low Medium High Very high

CLIMATE VULNERABILITY INDICATORS

	2010	TREND	2030	
AGGREGATE VULNERABILITY	●	↗	●	
HEALTH IMPACT	−	↑	+	
	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY
MALNUTRITION	3	270	4	555
DIARRHEA	Nil	Nil	Nil	Nil
MALARIA	Nil	Nil	Nil	Nil
CARDIOVASCULAR	Nil	30	1	110
RESPIRATORY	Nil	Nil	Nil	15
DENGUE	Nil	10	Nil	30
TOTAL	3	310	6	710
WEATHER DISASTERS	−	↑	+	
	DAMAGE	MORTALITY	DAMAGE	MORTALITY
FLOODS		18		34
STORMS & WILDFIRES		2		4
TOTAL WEATHER DISASTERS	$ 29 million	20	$ 86 million	38
HABITAT LOSS	●	→	●	
	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK
DESERTIFICATION	-25.8 per 100,000	N/A	-77.4 per 100,000	N/A
	COSTS AS SHARE OF GDP	TOTAL COSTS	COSTS AS SHARE OF GDP	TOTAL COSTS
SEA-LEVEL RISE	0.24%	$ 183 million	0.37%	$ 415 million
ECONOMIC STRESS	−	↑	−	
	IMPACT AS SHARE OF GDP	TOTAL IMPACT	IMPACT AS SHARE OF GDP	TOTAL IMPACT
LAND	-0.12%	-$ 91 million	-0.16%	-$ 179 million
MARINE	Nil	Nil	Nil	Nil
TOTAL	0.12%	$ 91 million	0.16%	$ 179 million

Nil = close to zero

All figures are annual expressed in either 2010 or for 2030. All numbers are purely estimative. The absolute economic figures are expressed as the relative impact (%) times current (IMF, 2009) USD PPP corrected GDP. 2030 absolute economic figures have, for illustrative purposes been corrected for expected future real GDP growth (the relative difference between FUND scenario 2010 and 2030).

Sources: UNDP, CIA Factbook, IMF, UNFCCC, NAPA/IPCC, CESIN

Acute+ Acute Acute- Severe+ Severe Severe- High+ High High- Moderate Low Increasing Stable Decreasing

MALDIVES

ACUTE

KEY FIGURES

POPULATION	345,000

ECONOMY	
2010 GDP PPP (US DOLLARS)	
TOTAL	$1.76 billion
PER CAPITA	$5,097
REAL GROWTH	3.45%
GDP BY SECTOR	
PRIMARY/EXTRACTIVE	6%
SECONDARY/PRODUCTIVE	17%
TERTIARY/SERVICES	77%
KEY INDUSTRIES	Tourism (30%)

SOCIO-ECONOMIC DEVELOPMENT

HUMAN DEVELOPMENT (RANK)	Medium (95th)
LIFE EXPECTANCY	71.1 years
ANNUAL POPULATION GROWTH	1.40%
ILLITERACY	3%
URBAN POPULATION	26%
ACCESS TO ELECTRICITY	No Data
GENDER DEVELOPMENT	77th
UNDERNOURISHED POPULATION (2002/04)	10%
LIVING BELOW POVERTY LINE ($2/DAY)	No Data
POPULATION WITHOUT IMPROVED WATER SOURCE	17%
OFFICIAL DEVELOPMENT ASSISTANCE (2008)	$54 million
PUBLIC HEALTH EXPENDITURE	14%
PUBLIC EDUCATION EXPENDITURE	15%

The 1,190 coral islands that form the Indian Ocean South Asian nation of Maldives are grouped into 26 atolls with an average height of only 1.5 metres (4 ft/11 inches) above sea-level. The highest point is just 2.3 metres (8 ft) above sea-level -- or 4 metres according to the country's National Adaptation Programme, which refers to the height of a prominent sand dune -- meaning the entire country falls within the low-elevation coastal zone. 80% of the country is actually less than 1 metre (3 ft) above sea-level. This makes Maldives one of the most vulnerable countries in the world to the impacts of climate change. The worst scenarios of warming projected by the IPCC would see the Maldives disappear completely under the sea well before the end of this century. Preserving certain land areas, such as the capital city of Male', may well be feasible in the medium term, but will be difficult to sustain given that sea-levels could rise 2 metres (7 ft) this century. The vulnerability of the Maldives is still extremely high even without taking its complete disappearance into account.

The incremental costs associated with protecting coastlines against erosion are a great burden on the Maldivian economy. Such measures are already estimated to cost the country a colossal 16% of lost GDP potential, and this figure will climb to 24% of today's GDP by 2030. Between 40 and 80% of all islands in the Maldives have already suffered severe coastal erosion, with more than 97% of inhabited islands reporting beach erosion in 2004, of which 64% reported severe beach erosion. The economic output of the Maldives economy is seriously held back by the need to divert resources from productive investments to efforts to protect valuable coastal property from erosion. The Maldives economy would see more significant growth if not weighed down by the constant stress of coping with this growing burden. Habitat loss is thus the number one vulnerability for the Maldives.

Economic stress is the country's next highest vulnerability and mainly reflects economic losses in the fisheries sector due to the warming and acidifying effect of the oceans on local fish stocks and catches. Tuna makes up more than 70% of the fishing industry, but sustainable catches are said to have peaked in 2005. Agriculture is also sensitive to growing water stresses on the Islands. Nevertheless, the Maldives' entire primary sector -- of which fisheries are a core part -- represents just 6-8% of the total economy. There is a great risk that the level of economic impacts suffered by the Maldives are not well represented here, in particular because the Monitor has not taken into account effects on other sectors of the economy. The tourism industry, which survives on beach holidaymakers, makes up almost one third of the Maldives economy. Three quarters of all tourists engage in snorkelling, and around one third engage in scuba diving. However, since tourism indirectly involves much of the rest of the nation's economy, the total impact of the tourism sector is estimated at closer to 67% of GDP.[305] Since fishing is also a key economic activity in Maldives, a full three quarters of the country's economy is under extreme stress due to climate change. Reef erosion to just one popular diving spot was found to have cost the local industry half a million dollars in lost revenue in just one year. The total disappearance of the Maldives' coral reefs is almost inevitable with the rate of temperature increase. As a result, the Maldives stands to lose the mainstay of its economy.

Health risks in the Maldives are also on the rise due to climate change. In remote, less developed island communities, malnutrition is still prevalent and is exacerbated by the agricultural and fishery

CLIMATE/GEOGRAPHY

CLIMATE ZONE	Tropcial Monsoon - Hot, Humid
PROJECTED RAINFALL CHANGE	Slight Decrease
TROPICAL CYCLONES	Yes
DESERTIFICATION	None
LOW-ELEVATION COASTAL ZONE (10M/33FT AND BELOW)	100%
FOREST COVER ANNUAL CHANGE	None

MIGRATION/DISPLACEMENT

EMIGRATION RATE	0.40%
IMMIGRANTS AS SHARE OF TOTAL POPULATION	1.10%
INTERNALLY DISPLACED PEOPLE	None

DISASTER HISTORY

TYPE	YEAR	KILLED	NUMBER OF PEOPLE AFFECTED	DAMAGE
STORM	1991		24,000	$30 million
TSUNAMI	2004	102	27,000	$470 million
FLOOD	2007		1,650	

EFFECTIVE ADAPTATION RESPONSES

FOCUS	IMPACT AREA	ACTION NO.	NAME	EFFECTIVENESS RATING	AVERAGE COST
COASTAL EROSION	Habitat Loss	3	Mangrove Restoration	High	$1 million+
FISHERIES/ MARINE BIODIVERSITY	Economic Stress	18	Shellfish Breeding Programmes	Medium	$0.25 million+
FISHERIES/ MARINE BIODIVERSITY	Economic Stress	19	Coral Restoration	Medium	$0.5 million
DISASTER RISK REDUCTION/ LAND PRESERVATION	Habitat Loss	1	Coastal Protection	Medium	$1 million
WATER STRESS/ SALT INTRUSION	Economic Stress	5	Rainwater Harvesting	Very High	$0.5 million
HEALTH	Health Impact	5	Immunization Programmes	High	$17 per child

NATIONAL ADAPTATION PROGRAMME FOR ACTION

DATE	**2007**
NUMBER OF PRIORITY PROJECTS	11
COMBINED PRIORITY PROJECT COSTS	$24 million
PROJECTS APPROVED FOR FUNDING	$9 million
KEY FOCUSES	Disaster Management and Capacity; Coastal Protection; Water Resources; Health Prevention; Building Design; Agriculture; Fisheries; Marine Ecosystems (Reefs)

impacts of climate change. Diarrhea due to increased water shortages and inadequate sanitation will grow to become a serious challenge if measures are not taken to address it. Vector-borne diseases are also likely to increase slightly with higher temperatures. Although the Maldives government reports that the country is experiencing growing epidemics, this report's analysis does not register such a health risk, because actual mortality due to climate-sensitive diseases is so low in a given year that it does not register in the Monitor calculations. This low mortality is a good indication that effective medical services are already in place in Maldives to minimize vulnerability to dengue and other health impacts.

While cyclone activity may be slightly increasing, the country has suffered relatively little damage due to extreme weather compared with other island nations. However, according to analysis in the county's NAPA, flooding from both rain and storm surges are becoming more common and can cause significant damage to affected communities. Sea-level rise does heighten the risk of disasters because of the increased exposure to devastating storm surges and tides. Every few centimetres of sea-level rise add slightly to the possible damage that another tsunami or storm wave could cause in areas where protective measures are not taken. The Maldives was badly affected by the Indian Ocean tsunami in 2004. Flood walls surrounding Male' did protect against major catastrophe in the nation's densely populated low-lying capital. The Maldives National Adaptation Programme for Action (NAPA) responds well to the variety of risks posed. However, it is unlikely to offset the level of impacts caused as a result of sea-level rise and ocean warming. The programme could not possibly prevent wholesale damage to the nation's unique coral reefs. Just one project estimated at around USD 1 million would be grossly insufficient to preserve even portions of the Maldives' diverse aquaculture. While USD 12 million for coastal protection of just one island underscores the phenomenal cost of adequately protecting a nation of thousands of islands against acute climate stresses.

Very low | Low | Medium | High | Very high

CLIMATE VULNERABILITY INDICATORS

	2010	TREND	2030	
AGGREGATE VULNERABILITY				
HEALTH IMPACT				
	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY
MALNUTRITION	2	10	4	20
DIARRHEA	1	Nil	1	5
MALARIA	Nil	Nil	Nil	Nil
CARDIOVASCULAR	Nil	Nil	1	Nil
RESPIRATORY	Nil	Nil	Nil	Nil
DENGUE	Nil	Nil	Nil	Nil
TOTAL	3	10	6	20
WEATHER DISASTERS				
	DAMAGE	MORTALITY	DAMAGE	MORTALITY
FLOODS		Nil		Nil
STORMS & WILDFIRES		Nil		Nil
TOTAL WEATHER DISASTERS	$0.31 million		$0.95 million	
HABITAT LOSS				
	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK
DESERTIFICATION	Nil	Nil	Nil	Nil
	COSTS AS SHARE OF GDP	TOTAL COSTS	COSTS AS SHARE OF GDP	TOTAL COSTS
SEA-LEVEL RISE	16%	$273 million	24%	$615 million
ECONOMIC STRESS				
	IMPACT AS SHARE OF GDP	TOTAL IMPACT	IMPACT AS SHARE OF GDP	TOTAL IMPACT
LAND	-0.13%	-$2.2 million	-0.18%	-$3.2 million
MARINE	-0.28%	-$4.7 million	-1.7%	-$43.5 million
TOTAL	-0.41%	-$6.9 million	-1.88%	-$48.2 million

Nil = close to zero

All figures are annual expressed in either 2010 or for 2030. All numbers are purely estimative. The absolute economic figures are expressed as the relative impact (%) times current (IMF, 2009) USD PPP corrected GDP. 2030 absolute economic figures have, for illustrative purposes been corrected for expected future real GDP growth (the relative difference between FUND scenario 2010 and 2030)

Sources: UNDP, CIA Factbook, IMF, UNFCCC, Napa/IPCC, CESIN.

Acute+ Acute Acute- Severe+ Severe Severe- High+ High High- Moderate Low Increasing Stable Decreasing

Dhuvaafaru island in the Maldives. Source: Stacey Winston/IFRC.

MOZAMBIQUE

ACUTE

KEY FIGURES

POPULATION	**21,585,000**
ECONOMY	
2010 GDP PPP (US DOLLARS)	
TOTAL	$21 billion
PER CAPITA	$981
REAL GROWTH	6.45%
GDP BY SECTOR	
PRIMARY/EXTRACTIVE	28.7%
SECONDARY/PRODUCTIVE	25.4%
TERTIARY/SERVICES	45.9%
KEY INDUSTRIES	Food & Beverages, Chemicals (fertilizer, soap, paints), Aluminium, Petroleum Products, Textiles

SOCIO-ECONOMIC DEVELOPMENT

HUMAN DEVELOPMENT (RANK)	Low (165th)
LIFE EXPECTANCY	48.37 years
ANNUAL POPULATION GROWTH	2.1%
ILLITERACY	54%
URBAN POPULATION	38.4%
ACCESS TO ELECTRICITY	6%
GENDER DEVELOPMENT	111th
UNDERNOURISHED POPULATION (2002/04)	44%
LIVING BELOW POVERTY LINE ($2/DAY)	74.7%
POPULATION WITHOUT IMPROVED WATER SOURCE	53%
OFFICIAL DEVELOPMENT ASSISTANCE (2008)	$2 billion
PUBLIC HEALTH EXPENDITURE	3.5%
PUBLIC EDUCATION EXPENDITURE	5%

The Southern African country of Mozambique, located on the Indian Ocean coast, is one of the fastest growing economies in Africa and the world. Its exposure to climate risks of virtually all kinds is nevertheless extreme, implying that the country's growth would be even more spectacular without the serious added stresses of climate change.

Mozambique still has far to go, though. Despite decades of sustained growth, it is still one of the least developed countries in the world, with almost 80% of the country living below the poverty line. Mozambique is one of the most acutely vulnerable countries in the world to the effects of climate change. It is suffering from severe multiple stresses, not just across the impact areas of health, economic stress, and weather disasters, but also from both types of habitat loss: Mozambique is one of just a handful of countries suffering high levels of both desertification and sea-level rise. Furthermore, all the impacts facing Mozambique are on the rapid increase.

The country registers highest vulnerability for habitat loss (Acute+/Acute+). Overall, Mozambique has only a small proportion of its surface area within the low elevation coastal zone. However, a large proportion of the country's key infrastructure and cities are located in the low-lying coastal land along the length of its extended coastline, which is exposed to the effects of sea-level rise. Mozambique is already estimated to be suffering multibillion-dollar impact losses and costs in economic potential in order to fend off these growing stresses. Climate-driven desertification, meanwhile, is estimated to be threatening the lands of some 5,000 additional people already today, and will threaten some 15,000 more people each year from 2030. Addressing the extreme pressures on human habitats under climate change-related stress in Mozambique will be costly and require strong external assistance. As these impacts rapidly expand towards 2030, they seriously risk holding back much socio-economic progress in the country.

The country's next greatest vulnerability is to health impacts (Severe+/Acute+) and economic stress (Severe+/Acute+). The country's high vulnerability to health impacts is driven in particular by a high prevalence of malaria all over the country and by above-average rates of malnutrition and diarrheal infection. Existing health programmes targeting reductions in these highly climate-sensitive diseases should be reinforced to take into account the added stresses, in particular of heat, that affect the spread of these deadly diseases.

Economic stresses due to reductions in agricultural yields, water, and biodiversity

CLIMATE/GEOGRAPHY

CLIMATE ZONE	Inter-tropical -- humid, dry, semi-arid, and modified due to elevation
PROJECTED RAINFALL CHANGE	Decrease
TROPICAL CYCLONES	Yes
DESERTIFICATION	Yes
LOW-ELEVATION COASTAL ZONE (10M/33FT AND BELOW)	3.2 %
FOREST COVER ANNUAL CHANGE	-0.2

MIGRATION/DISPLACEMENT

EMIGRATION RATE	4.2%
IMMIGRANTS AS SHARE OF TOTAL POPULATION	1.9%
INTERNALLY DISPLACED PEOPLE	None

DISASTER HISTORY

TYPE	YEAR	KILLED	NUMBER OF PEOPLE AFFECTED	DAMAGE
DROUGHT	1991		3.3 million	$50 million
STORM	1994	240	2.5 million	
FLOOD	2000	800	4.5 million	$419 million
FLOOD	2001	79	550,000	$36 million
DROUGHT	2002	9	600,000	
DROUGHT	2005		1.4 million	
FLOODS	2007	49	400,000	$171 million
DROUGHT	2007		520,000	
FLOOD	2008	140		
STORM	2008	9	220,000	$20 million

are already estimated at around 100 million dollars per year, or half a percent of GDP, and are set to increase by around 50% by 2030. Mozambique's economy is still highly dependent on agriculture, which accounts for nearly 30% of its GDP. Since agriculture is highly sensitive to climate changes, the structure of the country's economy is also weakly diversified against climate risks. While the primary sector represents roughly a third of the country's income, over 80% of the country's workforce is employed in the agricultural sector. So the social effects of economic impacts are likely to be especially acute, particularly among the rural poor. Fisheries are also slightly impacted already due to climate change, with losses linked to climate change building to around 40 million dollars a year by 2030.

Growing water shortages worsen economic stresses and health impacts such as malnutrition and diarrheal infections. Existing water stress in Mozambique is already above the norm, and rainfall has been dropping consistently over the last decades. Models also concur on a worsening of these stresses over the course of the twenty-first century. Measures must be taken if agricultural yields and human health are to keep pace with these changes. Water resources need to be carefully mapped and managed. New seed varietals, new irrigation techniques, and other measures should focus on recalibrating the economy towards more drought-resistant crops. Strategic planning might also be prudent to prioritize more rapid diversification of the economy into non-agricultural sectors that may be less sensitive to climate changes.

Finally, Mozambique shows least vulnerability to weather disasters (High-/Severe-). However, the country does experience and is exposed to major tropical storms, including cyclones -- just one such extreme weather event as recently as 2000 wiped more than 2% off the country's GDP. And floods and storms have regularly affected several millions of people. The Monitor most likely understates the vulnerability of Mozambique to extreme weather, since relatively low mortalities have been registered compared with other countries. However, the scales of the types of weather crises that are typical in the country are enormous, with sometimes one quarter of the population requiring emergency assistance.

In general, given that Mozambique differs substantially from the global norm in terms of vulnerabilities and impacts to the negative effects of climate change, a major reinforcement of the country's poverty-reduction and socio-economic development efforts should undertaken. Illiteracy, undernourishment, and a lack of access to clean water supplies are all problems that affect half of the population. Access to electricity is an unprecedented 6%, and extremely low amounts of Mozambique's GDP are spent on public health services and education. Much could be done to reduce gender inequalities, which would boost the country's adaptive capacity with respect to human health impacts, which particularly affect young children.

Given the scale of the stresses faced, the existing National Adaptation Programme for Action, with just four projects and only USD 2 million of approved funding, is woefully inadequate to deal with the scale of climate change affecting Mozambique. Adaptation efforts should be stepped up by several orders of magnitude, supported by external resources, in order to help the country, and in particular its poorest communities, address this new and dangerous burden.

EFFECTIVE ADAPTATION RESPONSES

FOCUS	ACTION NO.	IMPACT AREA	NAME	EFFECTIVENESS RATING	AVERAGE COST
SEA-LEVEL RISE, FLOODING, COASTAL EROSION, DISASTER RISK REDUCTION, COASTAL EROSION, FISHERIES	3	Habitat Loss	Mangrove Barriers and Restoration	High	$1 million+
SEA-LEVEL RISE/DISASTER RISK REDUCTION, COASTAL EROSION	1	Habitat Loss	Coastal Protection (Sea Walls and Dikes)	High	$1 million
DESERTIFICATION	10	Habitat Loss	Forestation	Very High	$5 million
DESERTIFICATION	8	Habitat Loss	Conservation and Restoration	High	$500,000
MALARIA	8	Health Impact	Insecticide-Treated Bed Nets	Very High	$5 per bed net
MALARIA	9	Health Impact	Indoor Residual Spraying	Very High	$9-24 per treatment
MALNUTRITION	1	Health Impact	Child Survival Programme with Nutrition Component	Very High	$2-10 per child
MALNUTRITION	2	Health Impact	School Health and Nutrition Programmes	Very High	$37 per DALY
DIARRHEA	7	Health Impact	Basic Sanitation Facilities	Very High	$60-160 per person
WATER AND HEAT STRESS/ AGRICULTURE	9	Economic Stress	Groundwater Management	High	$100,000
WATER AND HEAT STRESS/ AGRICULTURE	12	Economic Stress	Improved Crop Management	High	Unknown
WATER AND HEAT STRESS/ AGRICULTURE	2	Economic Stress	Soil Conservation	High	$2 million
WATER AND HEAT STRESS/ AGRICULTURE	14	Economic Stress	Salt-Tolerant Crops	High	$606 per acre, on average
DISASTER RISK REDUCTION	3	Weather Disasters	Disaster Management Training Programmes	Very High	$25,000-100,000
DISASTER RISK REDUCTION	1	Weather Disasters	Early Warning Systems	High	$1 million+ per system

NATIONAL ADAPTATION PROGRAMME FOR ACTION

DATE	2008
NUMBER OF PRIORITY PROJECTS	4
COMBINED PROJECT COSTS	$9.2 million
PROJECTS APPROVED FOR FUNDING	$2 million
KEY FOCUSES	Disaster Management and Capacity; Education and Capacity Building; Coastal Marine Ecosystems; Management of Water Resources

Very low Low Medium High Very high

CLIMATE VULNERABILITY INDICATORS

	2010	TREND	2030	
AGGREGATE VULNERABILITY	●	↑	●	
HEALTH IMPACT	+	↑	+	
	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY	DEATHS PER 100,000 PEOPLE	TOTAL EXCESS MORTALITY
MALNUTRITION	3	615	6	2050
DIARRHEA	3	550	5	1820
MALARIA	5	1100	10	3230
CARDIOVASCULAR	Nil	60	Nil	150
RESPIRATORY	Nil	15	Nil	40
DENGUE	Nil	Nil	Nil	Nil
TOTAL	11	2340	21	7290
WEATHER DISASTERS	+	→	−	
	DAMAGE	MORTALITY	DAMAGE	MORTALITY
FLOODS		13		27
STORMS & WILDFIRES		1		3
TOTAL WEATHER DISASTERS	$12.6 million	14	$39.4 million	30
HABITAT LOSS	+	↑	+	
	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK	SHARE OF POPULATION AT RISK	TOTAL POPULATION AT RISK
DESERTIFICATION	23 per 100,000	5,633	68 per 100,000	23,112
	COSTS AS SHARE OF GDP	TOTAL COSTS	COSTS AS SHARE OF GDP	TOTAL COSTS
SEA-LEVEL RISE	9%	$1.67 billion	14%	$4.1 billion
ECONOMIC STRESS	+	↑	+	
	IMPACT AS SHARE OF GDP	TOTAL IMPACT	IMPACT AS SHARE OF GDP	TOTAL IMPACT
LAND	-0.42%	-$78 million	-0.56%	-$164 million
MARINE	-0.03%	-$6 million	-0.18%	-$53 million
TOTAL	-0.45%	-$84 million	-0.74%	-$217 million

Nil = close to zero

All figures are annual expressed in either 2010 or for 2030. All numbers are purely estimative. The absolute economic figures are expressed as the relative impact (%) times current (IMF, 2009) USD PPP corrected GDP. 2030 absolute economic figures have, for illustrative purposes been corrected for expected future real GDP growth (the relative difference between FUND scenario 2010 and 2030)

Sources: UNDP, CIA Factbook, IMF, UNFCCC, NAPA/IPCC.

+ Acute+ ● Acute − Acute- + Severe+ ● Severe − Severe- + High+ ● High − High- ● Moderate ● Low ↑ Increasing → Stable ↓ Decreasing

An aerial view of houses in Haiti in the floods caused by the Tropical Storm Hanna. Source: UN Photo/Marco Dormino.

METHODOLOGY

METHODOLOGY

CLIMATE VULNERABILITY MONITOR

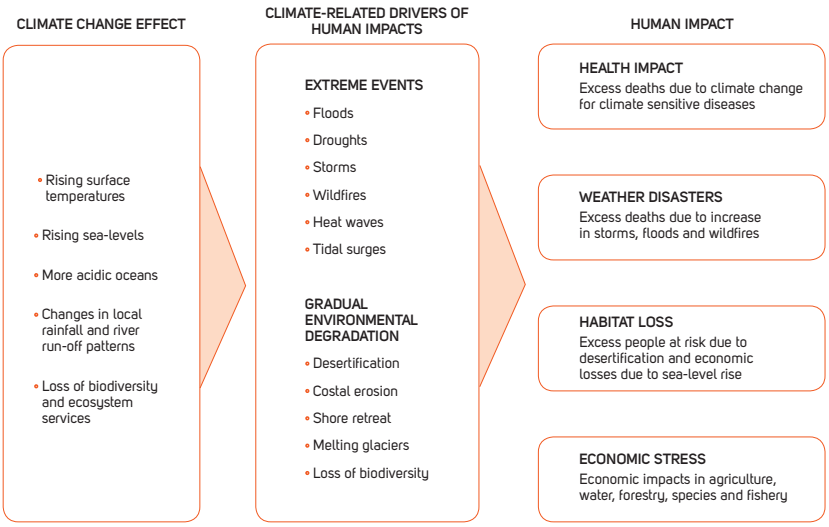
The Climate Vulnerability Monitor measures the impact of climate change on human health, weather, human habitat, and economies and combines those measures into an aggregate index that can be used to gauge our overall vulnerability to climate change on a national, regional, or global level.

There are many dimensions of human development for which the impact of climate change has not been projected in a way that can be applied to a global model. These include factors such as a community's access to education, water, sanitation, energy, and clean cooking environments. The Monitor also does not take into account such aspects of development as good governance, peace and stability, displacement, and gender issues.

Moreover, due to the limitations of available data, not all indicators used in the index have the same baseline years.

FIGURE 1: MODEL FOR CONSTRUCTION OF THE INDEX

The links from increased emission to human impact areas



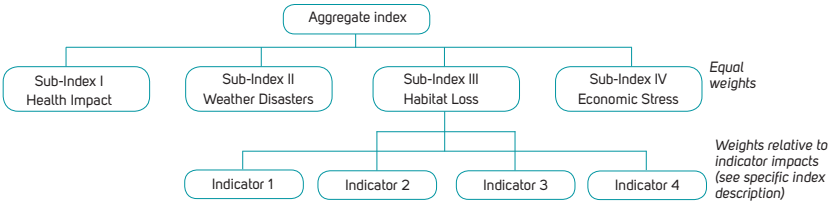
Source: Commons analysis

The Monitor is a work in progress in the sense that new data can be assimilated in the future as it becomes available. And as climate models develop significantly in the future, they will also strengthen the index.

STRUCTURE OF THE INDEX

The aggregate index on climate vulnerability comprises four sub-indices, each made up by a number of indicators.

FIGURE 2: STRUCTURE OF THE INDEX



Source: Commons analysis

INDICATORS AND AGGREGATION

A country's sub-index scores are summarized in an aggregate index score, which provides an indication of the overall impact of climate change.

STRUCTURE OF THE INDEX

INDEX ON CLIMATE VULNERABILITY	SUB-INDEX	INDICATORS
OVERALL INDEX	HEALTH IMPACT	• Malnutrition • Malaria • Diarrhea • Dengue • Cardiovascular diseases • Respiratory diseases
	WEATHER DISASTERS	• Floods • Storms • Wildfires
	HABITAT LOSS	• Desertification • Sea-level rise
	ECONOMIC STRESS	• Agriculture • Forestry • Water resources • Ecosystems • Fisheries

TIMEFRAMES, SOURCES, AND FREQUENCY OF DATA-UPDATES

Indicator scores are reported for Now/2010 and Near Term/2030. The selected data sources use different baseline years for their projections.
Data sources are also likely to be updated on different schedules.

MAIN SOURCES, DATA BASE YEAR, AND FREQUENCY OF UPDATES

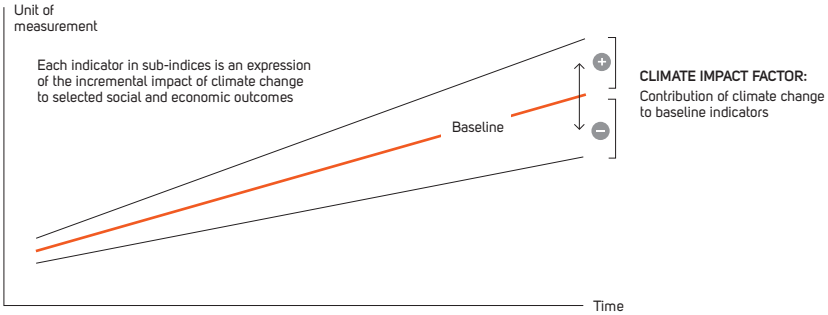
SUB-INDEX	MAIN SOURCES	DATA BASE YEAR (PROJECTION)	FREQUENCY OF UPDATES
HEALTH IMPACT	• WHO (2004) Global Climate Change • WHO (2009) Global Health Observatory – Global Burden of Disease Data	• 2004 (2010, 2030)	• New WHO estimates expected in 2011 • Disease burden updates expected every other year
WEATHER DISASTERS	• CRED (2010) Center for Research of the Epidemiology of Disasters • Munich Re (2010) NatCatSERVICE, Statistics on Natural Disasters	• 1990-2009 (2010, 2030)	• Annual updates
HABITAT LOSS	• DIVA (2003) Dynamic Interactive Vulnerability Assessment • PLACE (2010) The Place II Model: "Population, Landscape, and Climate Estimates" • Toth et al. (2005) Millennium Ecosystem Assessment Report	• 2000 (2010, 2030)	• DIVA: no update expected • PLACE: regular data updates
ECONOMIC STRESS	• FUND2.8n (2009) The Climate Framework for Uncertainty, Negotiation and Distribution (FUND) • Earth Trends WRI (2009) for maximum catch potential	• 2001 (2010, 2030) • 2005 (2010, 2030)	• FUND model has regular updates; however national-level indications are updated less frequently • Earth Trends updates are expected every other year

"CLIMATE EFFECT", "CLIMATE IMPACT FACTOR", AND CLIMATE SCENARIO

The index measures the impact of climate change through socio-economic indicators and scores countries based on this climate effect (CE).

The index assesses the climate effect in two ways:
- By attributing a climate impact factor (CIF) to baseline data derived from peer-reviewed scientific literature[306]
- By using existing complex models that calculate the climate effect[307]

FIGURE 3: CONTRIBUTION OF CLIMATE IMPACT FACTORS TO SOCIAL/ECONOMIC INDICATORS



Source: Commons analysis

Indicators score the effects of climate change on social and economic variables at the country level. This climate effect is calculated based on observed values of social and economic variables and the effects of climate change.

The extent climate change contributes to the development of a given variable is typically expressed as a climate impact factor (CIF). We compute an indicator's climate effect as follows:

$$CE = CIF \cdot variable$$

Variables are expressed in proportional terms to compare scores between countries: per GDP or per capita.

The other approach to indexing climate effect is using existing models. The two models used in the index are:
- FUND2.8n model, which estimates economic losses in various sectors of the economy
- Dynamic Interactive Vulnerability Assessment (DIVA), which estimates economic losses due to sea-level rise

In general, the various climate change models the Monitor uses have a starting point around the year 1990.

We have chosen medium-range climate scenarios in the sub-indices to calculate projections, except for in the sea-level rise indicator, where we have used a high-emission scenario. Recent research-based observations suggest that the high scenario is likely the most appropriate for sea-level rise projections.[308]

INDEX SCORING

The purpose of an index is to:
- Monitor evolution over time
- Draw attention to departures from average behaviour
- Enable comparison between countries

Constructing an index score based on a cross-section of univariate measures requires the choice of a transformation. In the context of monitoring climate impact, the transformation should balance the following goals:

- Preservation of the shape of the original distribution
- Unit-free measure
- Similarity of scale across indices
- Robustness, in the sense that a few extreme observations must not hide changes in remaining observations

We chose the dispersion measure as follows:

- An affine transformation preserves the shape of the original distribution
- Given a measure of dispersion measured in units of the original distribution, if the measure is used as a normalizing factor, the resulting score is both unit-free and similar with respect to scale across indices
- Robust dispersion measures such as mean absolute deviation or median absolute deviation are preferable, since they are somewhat insensitive to extreme observations
- Mean absolute deviation (MAD) is the choice for dispersion measure, since it weighs in extreme observations to some degree, while median absolute deviation does not

The index scores are constructed so that a CE of 100 indicates a neutral climate effect (CIF=0), while values above 100 indicate a negative climate effect, and values below 100 indicate a net gain from the impact of climate change.

The table below shows the range of CIF values in 2010 and 2030:

	CIF 2010 (LOW;HIGH)	CIF 2030 (LOW;HIGH)
MALNUTRITION	0; 0.091	0; 0.145
DIARRHEA	0; 0.038	0; 0.0654
MALARIA	0; 0.160	0; 0.248
DENGUE	0; 0.160	0; 0.248
CVD	-0.001; 0.003	-0.001; 0.005
RESP. DISEASES	-0.001; 0.003	-0.001; 0.005
FLOODS	0.115; 0.725	0.174; 0.815
WD OTHER	0.05	0.1
DESERTIFICATION	-0.007; 0.010	-0.02; 0.03
FISHERY	-0.026; 0.045	-0.13; 0.225

On the sub-index level, the countries have received an index score between 50 and 500. Data is standardized using the following formula:

$$\text{Index score} = ((\text{variable}_{i,t}/(10 \cdot \text{MAD}(\text{variable})_{2010})) + 1) \cdot 100$$

Where variable is an indicator representing each country (i) at t=2010, 2030.

In sub-indices, variations in data are collapsed by dividing with 10*MAD. By adding 1 and finally multiplying by 100, a neutral or zero climate effect is expressed by 100 while values above 100 express a negative effect of climate change. The MAD is kept at a constant 2010 level to allow for variations over time.

CLIMATE EFFECT VARIABLES

SUB-INDEX	CLIMATE EFFECT (CE) INDICATOR
HEALTH IMPACT	• Excess deaths due to climate change per capita
WEATHER DISASTERS	• Excess deaths due to storms, floods, and wildfires due to climate change per capita • Excess damage cost due to storms, floods, and wildfires due to climate change per GDP
HABITAT LOSS	• People at risk due to climate change-induced desertification • Cost per GDP due to climate change-induced sea-level rise
ECONOMIC STRESS	• Economic loss per GDP due to climate change

The countries are categorized in bands made in steps of ½*MAD from 100. The construction of the scoring means that one MAD of the 2010 score equals 10, resulting in the category bands listed below:

- Below 100 = low (reflecting positive impact of climate change)
- 100-104.99 (1/2*MAD from 100) = Moderate
- 105-109.99 = High -
- 110-114.99 = High +
- 115-119.99 = Severe -
- 120-124.99 = Severe +
- 125-129.99 = Acute -
- 130 and above = Acute +

The category bands have sub-factors or sub-bands ("+" or "-") for Acute, Severe, and High, but not for Moderate or Low. This is because:

- Roughly half of the countries assessed are not projected to face significant negative impacts overall from climate change in the near term (Moderate), and some may even experience small positive effects (Low)
- The indications for these countries are all quite similar, so there is limited basis for distinguishing between them in the Climate Vulnerability Monitor
- The focus of the Monitor is to offer guidance on countries facing High, Severe, and Acute impacts.

This construction method also enables an intuitive comparison between index scores Now (2010) and in the Near Term (2030). The impacts of climate change are expected to effect developments in countries depending on their particular vulnerabilities and exposures.

AGGREGATE INDEX SCORING

The purpose of the aggregate index scoring is to:

- Ensure that outliers in one of the sub-indices are not reflected disproportionally in the overall index
- Reflect highly impacted countries in one or more of the sub-indices

To achieve this scoring each category band on each sub-index is given a number:

- Below 100 = 1
- 100-104.99 = 2
- 105-109.99 = 3
- 110-114.99 = 4
- 115-119.99 = 5
- 120-124.99 = 6
- 125-129.99 = 7
- 130-134.99 = 8
- 135 and above = 9

The countries' average score on the sub-indices is calculated, and the countries are categorized using the legend below:

CATEGORY	LOW	HIGH
ACUTE	>5	
SEVERE	>4	<=5
HIGH	>3	<=4
MODERATE	>2	<=3
LOW		<=2

COUNTRIES INCLUDED AND SPATIAL SCALE

The index is calculated for 184 countries. Since its main objective is to enable comparisons between nations and sub-regions, it measures vulnerability at the national level. Assessment of vulnerability at the sub-national and local level is beyond the scope of this report.

Countries are divided into 20 regions for presentation purposes.

REGIONS AND COUNTRIES

REGION	COUNTRY
AUSTRALASIA	Australia, New Zealand
CARIBBEAN	Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago
CENTRAL AFRICA	Angola, Cameroon, Central African Republic, Chad, Congo, DRC Congo, Equatorial Guinea, Gabon, Sao Tome and Principe
CENTRAL AMERICA	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama
EAST AFRICA	Burundi, Comoros, Ethiopia, Eritrea, Djibouti, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, Zimbabwe, Uganda, Tanzania, Zambia
EAST ASIA	China, Japan, North Korea, South Korea, Mongolia
EASTERN EUROPE	Bulgaria, Belarus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, Slovakia, Ukraine
MIDDLE EAST	Bahrain, Cyprus, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Turkey, Yemen
NORTH AFRICA	Algeria, Libya, Morocco, Sudan, Tunisia, Egypt
NORTH AMERICA	Canada, United States of America
NORTHERN EUROPE	Denmark, Finland, Iceland, Ireland, Norway, Sweden, United Kingdom
PACIFIC	Solomon Islands, Fiji, Kiribati, Vanuatu, Micronesia, Marshall Islands, Palau, Papua New Guinea, Tonga, Tuvalu, Samoa
RUSSIA AND CENTRAL ASIA	Azerbaijan, Armenia, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, Uzbekistan
SOUTH AMERICA	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela
SOUTH ASIA	Afghanistan, Bangladesh, Bhutan, Sri Lanka, India, Iran, Maldives, Nepal, Pakistan
SOUTHEAST ASIA	Brunei, Myanmar, Cambodia, Indonesia, Laos, Malaysia, Philippines, Timor-Leste, Singapore, Vietnam, Thailand
SOUTHERN AFRICA	Botswana, Lesotho, Namibia, South Africa, Swaziland
SOUTHERN EUROPE	Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, Malta, Portugal, Slovenia, Spain, Macedonia
WEST AFRICA	Cape Verde, Benin, Gambia, Ghana, Guinea, Cote d'Ivoire, Liberia, Mali, Mauritania, Niger, Nigeria, Guinea-Bissau, Senegal, Sierra Leone, Togo, Burkina Faso
WESTERN EUROPE	Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland

The report also makes use of a variety of socio-economic groupings.

REGIONS AND COUNTRIES	
LANDLOCKED LEAST DEVELOPED COUNTRIES (LLDC)	Afghanistan, Armenia, Azerbaijan, Bhutan, Bolivia, Botswana, Burkina Faso, Burundi, Central African Republic, Chad, Ethiopia, Kazakhstan, Kyrgyzstan, Laos, Lesotho, Macedonia, Malawi, Mali, Mongolia, Nepal, Niger, Paraguay, Moldova, Rwanda, Swaziland, Tajikistan, Turkmenistan, Uganda, Uzbekistan, Zambia, Zimbabwe,
SMALL ISLAND DEVELOPING STATES (SIDS)	Antigua and Barbuda, Bahamas, Barbados, Belize, Cape Verde, Comoros, Cuba, Dominica, Dominican Republic, Fiji, Grenada, Guinea-Bissau, Guyana, Haiti, Jamaica, Kiribati, Maldives, Marshall Islands, Mauritius, Micronesia, Palau, Papua New Guinea, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Seychelles, Singapore, Solomon Islands, Suriname, Timor-Leste, Tonga, Trinidad and Tobago, Tuvalu, Vanuatu
INDUSTRIALIZED COUNTRIES (ANNEX I)	Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States
HIGH-GROWTH EMERGING COUNTRIES	Bangladesh, Brazil, China, Egypt, India, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, Russia, South Korea, Turkey, Vietnam
DEVELOPING COUNTRIES	Afghanistan, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia, Botswana, Brazil, Brunei, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Cote d'Ivoire, Cuba, Cyprus, Djibouti, Dominica, Dominican Republic, DRC Congo, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Laos, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Maldives, Mali, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, North Korea, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Qatar, Rwanda, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Solomon Islands, Somalia, South Africa, South Korea, Sri Lanka, Sudan, Suriname, Swaziland, Syria, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Tuvalu, Uganda, United Arab Emirates, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe

SUB-INDEX ON HEALTH IMPACT

SUB-INDEX HEALTH IMPACT			
SUB-INDEX	**CLIMATE EFFECT (CE)**	**CLIMATE IMPACT FACTOR**	**DATA SOURCE**
HEALTH IMPACT	Excess deaths per capita due to climate change for malnutrition (incl. acute respiratory infections) (%)	Climate impact factor (CIF) estimates for climate-sensitive diseases WHO (2004)[309]	WHO (2009)[310]
	Excess deaths per capita due to climate change for malaria (%)		
	Excess deaths per capita due to climate change for diarrhea (%)		
	Excess deaths per capita due to climate change for dengue (%)		
	Excess deaths per capita due to climate change for cardiovascular diseases (%)		
	Excess deaths per capita due to climate change for respiratory diseases (%)		

CALCULATION FROM WHO RISK FACTORS TO CLIMATE IMPACT FACTOR

WHO has estimated climate risk factors for a range of climate-sensitive diseases at the level of WHO regions (14) derived from complex models that account for a number of different climatic influences on climate-sensitive health disorders/diseases.

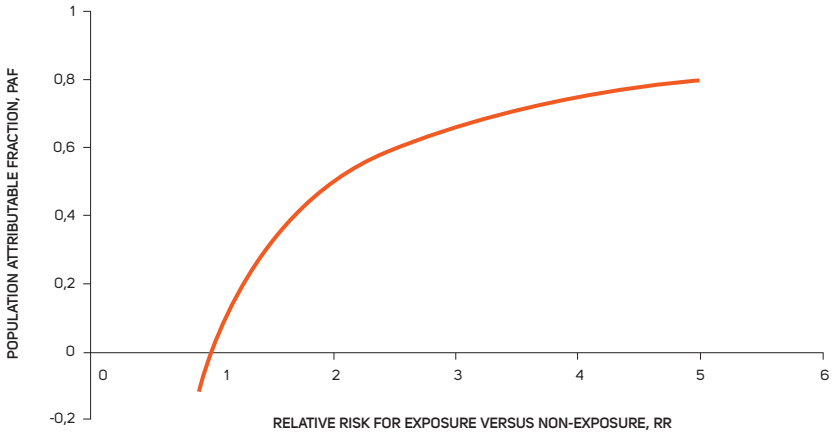
The interpretation assumes *total exposure*, meaning that all people, within each WHO region, are exposed equally to climate change. The equation below defines *PAF* (Population Attributable Fraction, *CIF*) as:

$$PAF = P\cdot(RR-1) / [P \cdot (RR-1)+1] = (RR-1) / [(RR-1)+1]$$

Where *P* = prevalence of exposure (assumed to equal 1), and *RR*=relative risk for exposed versus

non-exposed. In the case of climate change, the *RR* measure expresses the extra risk associated with the existence of abnormal weather patterns. For example, *RR*=2 indicates that the risk of dying due to flooding is twice as high in the case of climate change as it is the case of no climate change. The PAF expresses the fraction of risk -- for example, of deaths driven by climate -- and is, by construction, always smaller than 1.

The direct relationship between RR and PAF is illustrated in the figure below.



Baseline period: Baseline estimates of the burden of disease are taken from the WHO Burden of Disease Database, published 2004, estimates published 2009. This data is at the national level.

CALCULATION OF CLIMATE EFFECT AND INDEX SCORE

The WHO's 2009 "Global Health Observatory – Global Burden of Disease Database" report,[311] has baseline estimates of the burden of disease at the country level.

The WHO's 2004 "Comparative Quantification of Health Risk, Global and Regional Burden of Disease Attributable to Risk Factors" report,[312] has estimated climate impact factors (CIF) for climate-sensitive diseases at the level of WHO regions (14) derived from complex models that account for a number of different climatic influences on climate-sensitive health disorders/diseases.

The climate effect (CE) is calculated by multiplying the variable (disease burden) with the CIF, as shown in the formula below.

$$CE\_Malnutrition_{2010} = \frac{(CIF\_Malnutrition_{2010,country} \cdot Disease\ Burden_{2004,\ country})}{Population_{2004,country}}$$

Disease burden in 2010 uses the WHO's 2004,[313] while the disease burden in 2030 is projected using the UN 2010 estimates of population growth to 2030.[314]

The total excess deaths due to climate change for a country is the sum of the CE for diseases comprising the sub-index health impact (cf. Table 4 above):

$$SUM\ (CE_{2010,deaths}) = CE\_Malnutrition_{2010} + CE\_Malaria_{2010} + CE\_Diarrhea_{2010} + CE\_Dengue_{2010} + CE\_Cardiovascular\ Diseases_{2010} + CE\_Respiratory\ Diseases_{2010}$$

The sub-index score is calculated by using the index calculation formula below:

$$Index\ score_{2010} = ((SUM\ (CE_{2010,deaths}) / (10 \cdot MAD\ (SUM\ (CE_{2010,deaths})) + 1) \cdot 100$$

The calculation of 2030 estimates uses WHO 2004 CIF for 2030[315] and the disease burden projected for 2030, using population projections from the UN.[316]

CLIMATE SCENARIOS

The World Health Organization has three emission scenarios and three uncertainty scenarios resulting in a total of nine climate impact factors (CIF) per region.[317] For the purpose of the Health Impact sub-index, the two mid-range scenarios have been applied to measure the medium expected climate change impact:

- Mid-range: "Emission reduction resulting in stabilization at 750 ppm C02 equivalent by 2210 (s750)"[318]
- Mid-range uncertainty scenario is used "Making an adjustment for biological adaptation"[319]

Thus only one impact factor is chosen per region.

The WHO CIF estimates include 2010, 2020, and 2030 estimates. It uses the HadCM2 global climate model previously used by IPCC.[320]

SUB-INDEX ON WEATHER DISASTERS

SUB-INDEX WEATHER DISASTERS

SUB-INDEX	SUB-SUB-INDEX	CLIMATE EFFECT (CE) INDICATOR	CLIMATE IMPACT FACTOR (CIF)	SOURCE
WEATHER DISASTERS	DEATHS	Excess deaths per capita due to climate change for floods (%)	WHO estimates	WHO (2004)[321] CRED (2010)[322]
		Excess deaths per capita due to climate change for storms (%)	Hypothetical estimate 2010: 5% 2030: 10%	
		Excess deaths per capita due to climate change for wildfires (%)		
	DAMAGE COSTS	Excess damage costs relative to GDP due to floods (GDP USD %)	Hypothetical estimate 2010: 5% 2030: 10%	CRED (2010)[323]
		Excess damage costs relative to GDP due to storms (GDP USD %)		
		Excess damage costs relative to GDP due to wildfires (GDP USD %)		
		Excess damage costs relative to GDP due to natural disasters (GDP USD %)		Munich Re (2010)[324] GermanWatch (2010)[325]

CYCLICAL ADJUSTMENT

The sub-index is created using data from the Emergency Events Database (EM-DAT) and Munich Re NatCatSERVICE.[326] EM-DAT is maintained by the WHO Collaborating Centre for Research on the Epidemiology of Disasters.[327] EM-DAT includes data on a number of indicators (events, deaths, affected, economic damages) for a range of different disasters (drought, earthquake, epidemic, extreme temperature, flood, insect infestation, mass movement dry, mass movement wet, volcano, storm, wildfire).

The index also uses another set of data from the Munich Re NatCatSERVICE database[328] and from GermanWatch,[329] comprising some 28,000 data records on natural disasters. Approximately 1,000 events are recorded and analyzed every year.

The indicators used in the sub-index are deaths and damage costs, since these are regarded as the most reliable available data. Furthermore, only deaths and damage costs due to floods, storms, and wildfires are included in the index.

Floods, storms, and wildfires are highly variable phenomena. To obtain a more robust predictor of future events from past observations, the variable used to indicate risk of exposure to floods and storms is the average annual impact between 1990 and 2009.

The data on natural disasters is in many cases disparate.[330] The data source for deaths is exclusively EM-DAT. The approach for establishing damage costs is to combine data from EM-DAT and NatCatSERVICE databases to increase data reliability. The highest damage-cost value reflected in the two databases for the 20-year period is chosen for each country. This is done to cover lack of reporting in one of the databases, while there is little fear of overstating costs.

CALCULATION OF CLIMATE EFFECT AND INDEX SCORE

In the sub-index, two underlying indices for deaths and for damage costs are constructed.

The weather disaster deaths sub-index uses two types of climate impact factors (CIF). For floods the impact of climate change is calculated using a climate impact factor derived from WHO.[331] For storms and wildfires, 5% CIF is used in 2010, and 10% CIF is used in 2030 (see climate scenarios below).

The climate effect (CE) for excess deaths due to storms is calculated as follows for each country (2010 as example):

$$CE\_Storms\_Deaths_{2010} = \frac{(CIF\_Storms_{2010,country} \cdot Avg.\ Deaths_{1990\text{-}2009,country})}{Population_{2010,country}}$$

The total excess deaths per capita due to climate change for a country is the sum of the CE for storms, floods, and wildfires, comprising the underlying weather disaster deaths sub-index (cf. Table 5 above):

$$SUM\ (CE2010,deaths)) = CE\_Storm_{2010,deaths} + CE\_Floods_{2010,deaths} + CE\_WildFire_{2010,deaths}$$

Calculation of the index score is completed using the method described in the introductory section:

$$Index\ score_{2010} = ((SUM\ (CE_{2010,deaths}) / (10 \cdot MAD\ (SUM\ (CE_{2010deaths})) +1) \cdot 100$$

The same approach is used for constructing the weather disaster damage cost sub-index, again with storms as an example:

$$CE\_Storms\_DamageCost_{2010} = \frac{(CIF\_Storms_{2010,country} \cdot Avg.DamageCost_{1990\text{-}2009,country})}{GDP_{2010,country}}$$

Similarly to deaths, the CEs are summed and the index calculated. To reflect both deaths and damage cost in the weather disaster sub-index, the overall index score is constructed by adding the two indices with a weight of 20% of damage cost and 100% weighting of deaths.

$$Weather\ Disaster\ index\ score = index\ score\ deaths + 20\% \cdot (index\ score\ damage\ cost\ -100)$$

CLIMATE SCENARIOS

Rising temperatures increase the amount of energy in the atmosphere and also affect weather patterns. However, there is no scientific consensus on the impact of disasters in terms of projections for all disaster types of how this will affect impacts in terms of deaths and damage costs. Accordingly, the weather disaster sub-index uses two sets of climate scenarios.

There is a consensus that precipitation will intensify with rising temperatures impact on floods. We use the same WHO source to establish the impact of climate change on excess deaths from flood events as we used for the health impact index.

Storms and wildfires are highly variable over time, and it is challenging to statistically establish the climate change signal in observations of events over the last 20-30 years. Several groups of scientists are engaged in complex modelling to establish projections for how storm patterns will change with climate change. The effects are expected to be complex with different regions experiencing different event frequency, average of intensity, and intensity of top wind speeds.[332]

Consensus estimates have not yet been established for projections of these effects.

In line with its principles of applying due precaution and establishing relevant policy guidance, this report uses a set of hypothetical climate impact factors for areas where established estimates are not available – damage costs due to floods, and for excess deaths and damage costs due to storms and wildfires. These hypothetical factors are 5% for 2010 and 10% for 2030. These factors are moderate in comparison to studies of the increasing frequency of loss events,[333] and they are in line with regional projections for instance for the United States.[334] It is expected that improved estimates will be available by the time that the next version of this report is published.

For Floods, The World Health Organization has three emission scenarios and three uncertainty scenarios giving a total of nine Climate Impact Factors (CIF) per region.[335] For the purpose of the floods CIF, the two mid-range scenarios have been applied to measure the medium expected climate change impact:

- Mid-range: "Emission reduction resulting in stabilization at 750 ppm C02 equivalent by 2210 (s750)"[336]
- Mid-range uncertainty scenario is used "Making an adjustment for biological adaptation"[337]

Thus only one impact factor is chosen per region.

SUB-INDEX ON HABITAT LOSS

HABITAT LOSS

SUB-INDEX	SUB-SUB-INDEX	CLIMATE EFFECT (CE) INDICATOR	CLIMATE IMPACT FACTOR (CIF)	SOURCE
HABITAT LOSS	DESERTIFICATION	Excess population per capita at risk due to climate change in climatic zone: dry, steppe vegetation type (%)	IMAGE 2.2 estimates in the Millennium Ecosystem Assessment[338]	PLACE II (2010)[339] Toth et al. (2005)[340]
		Excess population per capita at risk due to climate change in climatic zone: Dry, Steppe Vegetation Type, Subtropical desert with average temperature >18 °C.		
		Excess population per capita at risk due to climate change in climatic zone: dry, steppe vegetation type, cool dry climate, middle latitude deserts.		
		Excess population per capita at risk due to climate change in climatic zone: dry, steppe vegetation type, temperature of warmest month < 18 °C.		
	SEA-LEVEL RISE	Tidal basin nourishment costs relative to GDP (USD) (%)	Economic impacts calculated in DIVA	DIVA (2003)[341]
		Beach nourishment costs relative to GDP (USD) (%)		
		Land loss costs relative to GDP (USD) (%)		
		Migration costs relative to GDP (USD) (%)		
		River dike costs relative to GDP (USD) (%)		
		River flood costs relative to GDP (USD) (%)		
		Salinity intrusion costs relative to GDP (USD) (%)		
		Sea dike costs relative to GDP (USD) (%)		
		Sea flood costs relative to GDP (USD) (%)		
		Wetland nourishment costs relative to GDP (USD) (%)		

CALCULATION OF CLIMATE EFFECT

The Sea-Level Rise Indicator in the sub-index is calculated by using a set of variables indicating the projected economic losses as a share of GDP due to sea-level rise caused by climate change from the Dynamic Interactive Vulnerability Assessment (DIVA) tool;[342] a geographic information system (GIS)-based tool to assess impacts and vulnerability to sea-level rise at scales from coastal segment up to global. It comprises a database, a series of algorithms, and a graphical user interface. In the DIVA database, the world's coastlines are divided into 12,148 segments with an average coastal segment length of 70km. DIVA provides a multitude of parameters for each of the segments, including population density, frequency and height of storm surges, and coastal wetland areas. These are used as inputs for the extended sea-level rise cost function. DIVA also contains various data at other scales, including countries, major rivers, tidal basins, and administrative units (states, prefectures, etc.).

The economic losses modelled in the DIVA due to sea-level rise is the cost of:

- Tidal basin nourishment (adaptation cost)
- Beach nourishment (adaptation cost)
- Land loss (losses)
- Migration (adaptation cost)
- River dike (adaptation cost)
- River flood (losses)
- Salinity intrusion (losses)
- Sea dike (adaptation cost)
- Sea flood (losses)
- Wetland nourishment (adaptation cost)

Each of the cost components is derived from the DIVA model in 2010 and 2030 and the climate effect is calculated simply by dividing the cost with GDP.

$$CE\_Land\ Loss_{2010,country} = \frac{Cost\ of\ Land\ Loss_{2010,country}}{GDP_{2010,country}}$$

We can use the same method to calculate the sea-level rise index score as we used in the Health Impact and Weather Disaster sections:

- Adding all CE effects
- Calculating the index score

$$Index\ score_{2010} = ((SUM\ (CE_{2010,gdp}) / (10 \cdot MAD\ (SUM\ (CE_{2010,gdp})) + 1) \cdot 100$$

The Desertification Indicator in the sub-index is calculated by using a variable indicating the share of the population living in areas at risk of desertification from the PLACE II database (Population, Landscape, and Climate Estimates).[343] This data set has been released as part of SEDAC's National Aggregates of Geospatial Data Collection.

SEDAC, the Socioeconomic Data and Applications Center, is one of the Distributed Active Archive Centers (DAACs) in the Earth Observing System Data and Information System (EOSDIS) of the U.S. National Aeronautics and Space Administration. PLACE II is managed by the Center for International Earth Science Information Network (CIESIN) at Columbia University.[344]

PLACE II estimates the number of people (head counts and percentages) and the land area (square kilometres and percentages) represented within each class of a number of demographic, physical, biological, and climatic variables for each country around the world, for the years 1990 and 2000.[345]

The measure used in the sub-index is the share of populations living in areas that are at risk of desertification (defined as population in climatic zones that is classified as dry, steppe vegetation type).

The impact of climate change on the population at risk to desertification has been derived from the Millennium Ecosystem Assessment Report (1999) using the IMAGE model that is developed by the IMAGE team under the authority of the Netherlands Environmental Assessment Agency (PBL). IMAGE is used to provide regional estimates of desertification.[346]

Climate impact factors are assumed to follow a linear trajectory from 2000 to 2050, as suggested by the four scenarios in the IMAGE2.2. model. Thus, scores for 2010 and 2030 can be derived by combining the IMAGE model projections and the PLACE model baseline data from 2000.

We calculate the desertification index similarly to how we calculate the other indices, except that we divide the scores 20*MAD in the index score construction:

Index score = ((SUM (CE_{2010,pop_at_risk}) / (20 · MAD (SUM (CE_{2010,pop_at_risk})) +1) ·100

This deviation from the general index calculation rule is done to make the desertification sub-index comparable to the sea-level rise sub-index due to many extreme values in the former index.

The sub-index score is calculated by adding the score on the Sea-Level Rise Indicator and the score on the Desertification Indicator and subtracting 100. This combination of the two effects allows the sub-index to indicate which countries are most exposed to either sea-level rise or desertification and to particularly highlight the countries that are exposed to both effects. This index thus avoids penalizing countries that are landlocked or not exposed to desertification.

Habitat Loss index score = (Index score SLR + Index score desertification) - 100

CLIMATE SCENARIOS

The desertification risk measure is a simple average of the different IMAGE projections listed below.[347]

- Global Orchestration
- Order from Strength
- TechnoGarden
- Adapting Mosaic

For the sea-level rise cost calculations used in DIVA, the A1FI scenario is used as the projection method.

SUB-INDEX ON ECONOMIC STRESS

ECONOMIC STRESS

SUB-INDEX	CLIMATE EFFECT (CE) INDICATOR	CLIMATE IMPACT FACTOR (CIF)	SOURCE
ECONOMIC STRESS	Costs relative to GDP (USD) due to effect on water	Economic impacts calibrated in the FUND2.8n model	FUND (2009)[348]
	Costs relative to GDP (USD) due to effect on agriculture		
	Costs relative to GDP (USD) due to effect on forestry		
	Costs relative to GDP due to effect on ecosystems/biodiversity		
	Change in fishery exports relative to GDP (USD) due to effect on fisheries	Estimate of change in Maximum catch potential	Cheung et al. (2010)[349] Earth Trends WRI (2010)[350]

CALCULATION OF CLIMATE EFFECT

We calculate the Economic Stress Sub-index using a set of variables indicating the projected economic losses in different economic sectors as a share of GDP due to climate change.

Estimates for four economic sectors are based on the FUND 2.8n model. We calculate the Climate Effect by use of the FUND model (Climate Framework for Uncertainty, Negotiation and Distribution).[351] FUND is an integrated assessment model of climate change. The model links exogenous population and per capita income scenarios with simple models of technology, economics, emissions, atmospheric chemistry, climate and sea-levels in order to estimate impacts such as migration, disease burdens and economic effects on a sector basis. The model runs in steps of 5 years from 1950 to 2100 and covers 207 countries. The FUND2.8n model is based on the more sophisticated FUND2.8 model that provides annual estimates of outcomes for 16 regions up to 2030. All estimates in the FUND model are made with 1995 US dollars as the benchmark year.

One notable change has been made to the FUND model, namely to reduce in half the "water resources sensitivity parameter with regard to temperature change" for the "Former Soviet Union" region. This rationale for the change was as follows:

- Former Soviet Union water resources impact is an outlier value that overshadows the impacts in other regions
- To improve the sensitivity of the Economic sub-index to negative impacts in other regions

The sub-index combines indicators of climate change impacts on economic sectors that are stressed by climate change.

- Land sectors (Agriculture, Forestry, Water and Biodiversity): climate change related loss or gain in economic output in these sectors in 2010 and 2030.
- Marine sector (Fisheries): climate change related loss or gain in the economic value of exports of the fisheries sector in 2010 and 2030

We calculate economic loss in fisheries using Cheung et al. 2010 estimates.[352] Cheung et al. estimate the change in maximum catch potential due to climate change. The higher (numerically) the latitude, the larger the increase in maximum catch potential, and the opposite holds true for low-latitude countries. Thus, tropical countries close to the equator face a decreasing maximum catch potential, while especially northern countries experience gains.

Cheung et al. show specific estimates for 20 countries. These are taken directly as climate impact factors (CIFs). The countries not listed are given general risk factors using the specifications below:

- Countries > 55 lat = 0,3
- Countries in the tropics < 0,23 (num) = -0,2

Calculation of the index scores follows the same procedure as the other sub-indices

$$CE\_Land\_Sectors2010,country = \frac{Cost\ of\ Land\ Sectors2010,country}{GDP_{2010,country}}$$

And

$$SUM\ (CE_{2010,gdp}) = CE\_Land\_Sectors_{2010,gdp} + CE\_Marine\_Sector_{2010,gdp}$$

And

$$Index\ score = ((SUM\ (CE_{2010,gdp}) / (10 \cdot MAD\ (SUM\ (CE_{2010,gdp})) +1) \cdot 100$$

CLIMATE SCENARIOS

The FUND scenario is based on the EMF14 Standardized Scenario and lies somewhere between the IS92a and IS92f scenarios.[353] The scenario used for fisheries is the SRES (Special Report on Emissions Scenarios) A1B scenario. This scenario assumes that the greenhouse gas concentration will be stabilized at 720 ppm by the year 2100. It describes a world of very rapid economic growth, low population growth, rapid introduction of new and more efficient technologies, and moderate use of resources with a balanced use of technologies.

EXAMPLE SUB-INDEX CALCULATION: HEALTH IMPACT IN BANGLADESH

CODE	VARIABLE	CALCULATION	BASELINE	2010	2030
HI1	Disease Burden Malnutrition (1000 persons)	-	132		
HI2	Disease Burden Diarrheal (1000 persons)	-	74		
HI3	Disease Burden Malaria (1000 persons)	-	6		
HI4	Disease Burden Dengue (1000 persons)	-	2		
HI5	Disease Burden CVD (1000 persons)	-	290		
HI6	Disease Burden Resp. Diseases (1000 persons)	-	65		
HI7;I13	CIF Malnutrition	-		0,09	0,15
HI8; HI14	CIF Diarrheal	-		0,04	0,07
HI9; HI15	CIF Malaria	-		0,00	0,01
HI10; I16	CIF Dengue	-		0,00	0,01
HI11; I17	CIF CVD	-		0,00	0,00
HI12; 18	CIF Resp. Diseases	-		0,00	0,00
HI19	Population WHO 2004, (1000 persons)	-	150528		
HI20	Population UN 2030 (1000 persons)	-	204927		
HI21	Population Growth Factor, 2004 to 2030	(HI20-HI19)/HI19+1	1		
HI22; I28	CE Malnutrition	**2010:** HI7*HI1; **2030:** HI13*HI1*HI21		11,98	26,07
HI23; HI29	CE Diarrhea	**2010:** HI8*HI2; **2030:** HI14*HI2*HI21		2,83	6,55
HI24; HI30	CE Malaria	**2010:** HI9*HI3; **2030:** HI15*HI3*HI21		0,00	0,09
HI25; HI31	CE Dengue	**2010:** HI10*HI4; **2030:** HI16*HI4*HI21		0,00	0,03
HI26; HI32	CE CVD	**2010:** HI11*HI5; **2030:** HI17*HI5*HI21		0,87	1,97
HI27; HI33	CE Resp. Diseases	**2010:** HI12*HI6; **2030:** HI18*HI6*HI21		0,19	0,44
HI34; HI35	CE TOTAL	**2010:** sum(HI22;HI27); **2030:** sum(HI28;HI33)		15,87	35,14
HI36; I37	CE TOTAL per capita	**2010:** HI34/HI19 **2030:** HI35/HI20		0,000105	0,000171
HI38; I39	MAD 2010	Mean(abs(HI36-mean(HI36)))		0,0000545	0,0000545
HI40; I41	Health sub-index	**2010:** (HI36/(HI38*10)+1)*100;		119,34	131,46
HI42; HI43	Category	**2030:** (HI37/(HI39*10)+1)*100		HIGH +	ACUTE -

EXAMPLE SUB-INDEX CALCULATION: WEATHER DISASTERS IN BANGLADESH

CODE	VARIABLE	CALCULATION	BASELINE	2010	2030
WD1	Weather Disaster Burden Floods (average # of persons, 1990 - 2009)	-	267.40		
WD2	Weather Disaster Burden Storms (average # of persons, 1990 - 2009)	-	7410.05		
WD3	Weather Disaster Burden Wildfire (average # of persons, 1990 - 2009)	-	0.00		
WD4; WD7	CIF Floods	-		0.12	0.17
WD5; WD8	CIF Storms	-		0.05	0.10
WD6; WD9	CIF Wildfires	-		0.05	0.10
WD10	Population World Bank (average, 1990-2008)	-	138106.23		
WD11	Population UN 2030 (1000 persons)	-	204926.85		
WD12	Population Growth Factor, 1990-2008 avg – 2030	(WD11-WD10)/WD10+1	1.48		
WD13; WD16	CE Floods	**2010:** WD1*WD4; **2030:** WD1*WD7*WD12		30.76	68.86
WD14; WD17	CE Storms	**2010:** WD2*WD5; **2030:** WD2*WD8*WD12		370.50	1099.53
WD15; WD18	CE wildfires	**2010:** WD3*WD6; **2030:** WD3*WD9*WD12		0.00	0.00
WD19; WD20	CE (deaths) TOTAL	**2010:** sum(WD4;WD6); **2030:** sum(WD7;WD9)		401.27	1168.39
WD21; WD22	CE (deaths) TOTAL per capita	**2010:** WD19/(WD10*1000); **2030:** WD20/(WD11*1000)		2.90548E-06	5.7015E-06
WD23; WD24	MAD 2010, deaths	Mean(abs(WD21-mean(CE deaths Total per capita 2010)))		0.000001	0.000001
WD25; WD26	Weather disasters sub-sub-index (deaths)	**2010**: (WD21/(WD23*10)+1)*100; **2030:** (WD22/(WD24*10)+1)*100		130.68	160.21
WD27	Weather Disaster Burden Floods (average damage costs 1990 - 2009, 1000 USD)	-	394215.00		
WD28	Weather Disaster Burden Storms (average damage costs 1990 - 2009, 1000 USD)	-	263875.00		
WD29	Weather Disaster Burden Wildfires (average damage costs 1990 - 2009, 1000 USD)	-	0.00		
WD30	MunichRE* (average costs per GDP, 1990-2008)	-	0.0181		
WD31; WD32	CIF Damage Costs	-		0.05	0.1
WD33	GDP FUND (average, 1995, 2000, 2005, 2010) (billion 1995 USD)	-	56.7235		
WD34	GDP FUND 2030 (billion 1995 USD)	-	152.796		
WD35	GDP Growth Factor	-	2.69		
WD36	Damage Costs (1000 1995 USD)	MAX(sum(WD27:WD29; WD30*WD33*100000)	1026695.59		
WD37; WD38	CE Damage Costs	**2010:** WD36*WD31; **2030:** WD36*WD32*WD35		51334.78	276561.48
WD39; WD40	CE Damage Costs per GDP	**2010:** WD37/(WD33*1000000); **2030:** WD38/(WD34*1000000)		0.0009	0.0018
WD41; WD42	MAD 2010, Damage Costs	Mean(abs(WD39-mean(CE damage costs per GDP 2010)))		0.0006	0.0006
WD43; WD44	Weather Disasters sub-sub-index (damage costs)	**2010:** (WD39/(WD41*10)+1)*100; **2030:** (WD40/(WD42*10)+1)*100		114.28	128.55
WD45; WD46	Weather Disasters sub-index	**2010:** ((WD25-100)+(WD43-100)*0.2)+100; **2030:** ((WD26-100)+(WD44-100)*0.2)+100		133.54	165.92
WD47; WD48	Category	-		Acute+	Acute+

*storms and floods, as well as temperature extremes and mass movements (heat and cold waves, etc.)

EXAMPLE SUB-INDEX CALCULATION: HABITAT LOSS IN BANGLADESH

CODE	VARIABLE	CALCULATION	BASELINE	2010	2030
HL1	Population living in drylands PLACE 2000	-	0		
HL2; HL3	CIF desertification	-		0.0045	0.0135
HL4; HL5; HL6	Population FUND 1000 persons	-	129790.7	151123.72	184852.8649
HL7; HL8	Population growth factor	**2010:** (HL5-HL4)/HL4+1 **2030:** (HL6-HL4)/HL4+1		1.164365	1.424238
HL9; HL10	CE desertification	**2010:** HL1*HL2*HL7 **2030:** HL1*HL3*HL8		0	0
HL11; HL12	CE desertification per capita	**2010:** HL9/HL5 **2030:** HL10/HL6		0	0
HL13; HL14	MAD 2010, desertification	Mean(abs(HL11-mean(CE desertification per capita 2010)))		0.0003534	0.0003534
HL15; HL16	Desertification sub-sub-index (deaths)	**2010:** (HL11/(HL13*10)+1)*100; **2030:** (HL12/(HL14*10)+1)*100		100	100
HL17; HL18	CE SLR costs (million USD)	-		353.10	1447.31
HL19	GDP FUND 2010 (billion USD)	-	76.974		
HL20; HL21	CE SLR costs per GDP	**2010:** HL17/(HL19*1000); **2030:** HL18/(HL19*1000)		0.0046	0.0188
HL22; HL23	MAD 2010, SLR	Mean(abs(HL20-mean(CE SLR costs per GDP)))		0.0211	0.0211
HL24; HL25	Desertification sub-sub-index (deaths)	**2010:** (HL20/(HL22*10)+1)*100; **2030:** (HL21/(HL23*10)+1)*100		102.176	108.921
HL26; HL27	Habitat Loss sub-index	**2010:** HL15+HL24-100; **2030:** HL16+HL25-100		102.1764	108.9207
HL28; HL29	Category	-		MODERATE	HIGH-

EXAMPLE SUB-INDEX CALCULATION: ECONOMIC STRESS IN BANGLADESH

CODE	VARIABLE	CALCULATION	BASELINE	2010	2030
ES1	Fishery Exports 2005 (million 2005 USD)	-	359.47		
ES2	GDP World Bank 2005 (billion 2005 USD)	-	60.278		
ES3	GDP FUND 2005 (billion 1995 USD)	-	62.856		
ES4	GDP FUND 2030 (billion 1995 USD)		152.796		
ES5	GDP FUND 2010 (billion USD)	-	76.974		
ES6	Fishery Exports relative to GDP 2005	ES1/(ES2*1000)	0.005964		
ES7	Fishery Exports 2005 (million 1995 USD)	ES6*ES3*1000	374.873		
ES8	GDP Growth Factor	(ES4-ES3)/ES3+1	2.431		
ES9; ES10	CIF Fisheries	-		-0.025	-0.125
ES11; ES16	CE Fisheries (million 1995 USD)	2010: (ES7*ES9)*-1; 2030: (ES7*ES10*ES8)*-1		9.3718296	113.9097126
ES12; ES17	CE Agriculture (million 1995 USD)	-		-3.616149	-7.937206
ES13; ES18	CE Forestry (million 1995 USD)	-		-4.113147	-10.387434
ES14; ES19	CE Water (million 1995 USD)	-		105.072469	273.70844
ES15; ES20	CE Ecosystems (million 1995 USD)	-		2.199358	8.033951
ES21; ES22	CE Total	2010: sum(ES11:ES15); 2030: sum(ES16:ES20)		108.914	377.327
ES23; ES24	CE Total per GDP	2010: ES21/(ES5*1000); 2030: ES22/(ES4*1000)		0.001415	0.002469
ES25; ES26	MAD 2010	Mean(abs(ES23-mean(CE total per GDP 2010)))		0.00213	0.00213
ES27; ES28	Economic Stress subindex	2010: (ES23/(ES25*10)+1)*100;		106.647025	111.600803
ES29; ES30	Category	2030: (ES24/(ES26*10)+1)*100		HIGH-	HIGH+

ADAPTATION PERFORMANCE REVIEW

Whereas the Index on climate vulnerability highlights key vulnerabilities to climate change through the lens of estimated/measurable impacts on human society, the Adaptation Performance Review is a rating system on adaptive effectiveness that assesses measures known to be effective to a specific degree in limiting the impact on vulnerable populations as identified in the Climate Vulnerability Monitor/Index section of the report. The key criteria used in the rating system are summarized in the table below:

CRITERIA	OPERATIONAL QUESTIONS
COST-EFFECTIVENESS	• Cost-effectiveness rating • Time horizon (from implementation to impact) • Variability
CO-BENEFITS	• Co-benefits rating • Equity • Variability
FEASIBILITY	• Implementation risks • Sensitivity to exogenous factors • Variability
SCALABILITY	• Technical specifications and guidelines • Training programmes • LDC relevance • Case examples
EVIDENCE-BASED	• Peer-reviewed studies • Type of assessments • Linked to vulnerability assessment • Recognition by policy-makers

CATALOGUE OF ADAPTIVE MEASURES

We have built up the catalogue of adaptation intervention sets based on a comprehensive review of national programmes of action and pilot schemes. We selected adaptation interventions sets based on bottom-up reviews of projects that are currently being planned or implemented, and we have categorized them according to the most relevant areas of vulnerability following the Index structure.[354] The report does not cover exogenous factors such as legislation, local capacities, policy frameworks, private sector strategies of risk transfer, etc. This could create a bias towards project-based adaptation measures as opposed to adaptation that addresses an underlying governance.

DESK REVIEW APPROACH

We identified and rated the adaptive measures primarily based on a desk review of published materials. We focused on material that is published either in a peer-reviewed source or by an institution that is internationally recognized as a credible source of information on climate change and adaptation issues.[355]

CATEGORIES OF MEASURES IN THE CATALOGUE

The catalogue is divided into a number of categories to ensure a good distribution of measures across the key areas of vulnerability and types of interventions.

The intervention sets fall into the four index categories:
- Health
- Weather Disasters
- Habitat Loss
- Economic Stress

RATING METHODOLOGY

The indicator set covers the key factors that determine whether a specific intervention is attractive to a community that is vulnerable to a certain type of climate impact. Each adaptation intervention set is rated based on a standard approach:

- Indicator set across a set of key dimensions of attractiveness
- Qualitative criteria and rating guide for each indicator
- System for aggregating ratings across criteria and indicators

INDICATORS AND RATING SYSTEM

Each indicator is operationalized through a set of qualitative criteria that are assigned scores and weights to make up a compound rating on each indicator.

INDICATOR RATING SYSTEM GUIDE

CRITERIA	OPERATIONAL QUESTIONS	HIGHEST (5)	LOWEST (1)	SUB-WEIGHT	WEIGHT
COST-EFFECTIVENESS (CE)	Cost-effectiveness rating	Very high/self-financing	Very low	50%	40%
	Time horizon	Short term (within 1 year)	10+ years	25%	
	Variability	Fully consistent	Inconsistent	25%	
CO-BENEFITS (CB)	Co-benefits rating	Large impact on dev./hum indicators	Negative	50%	15%
	Equity	All groups, incl. poorest	Mostly benefit wealthy	25%	
	Variability	Fully consistent	Inconsistent	25%	
FEASIBILITY (F)	Implementation risks	Always succeeds	Mostly likely to fail	50%	15%
	Sensitivity to exogenous factors	Not sensitive	Very sensitive	25%	
	Variability	Fully consistent	Inconsistent	25%	
SCALABILITY (S)	Tech specs and guidelines	Rich and accessible doc	Little, hard-to-get info	25%	15%
	Training programmes	Many, affordable	No programmes	25%	
	LDC relevance	Very relevant	Not relevant	25%	
	Case examples	Many, well-documented	No case examples	25%	
EVIDENCE (E)	Peer reviewed studies	Several, high-profile	None	40%	15%
	Type of assessments	Empirical, detailed	Qualitative, general	30%	
	Linked to vulnerability assessment	Specific	Unspecific	15%	
	Recognition by policy-makers	High, frequent	Low	15%	

An overall rating is calculated by combining the scores across the indicators.

The rating scores are consequently made on a 1-5 scale, resulting in the category bounds listed below:

- >0-1 = Very Low
- >1-2 = Low
- >2-3 = Medium
- >3-4 = High
- >4-5 = Very High

A high rate of livestock deaths is reported from Ethiopia's Ogaden region due to drought and other factors. Source: UN Photo/Gijs van't Klooster.

A child steps over stones to avoid flooded streets just outside of Dakar, Senegal, where heavy rains caused severe flooding.
Source: Ricci Shryock/IFRC.

MONITOR DATA TABLES

ACUTE

COUNTRY	OVERALL VULNERABILITY FACTOR 2010	OVERALL VULNERABILITY FACTOR 2030	OVERALL CHANGE IN IMPACT	HEALTH IMPACT 2010	HEALTH IMPACT 2030	HEALTH FACTOR CHANGE
AFGHANISTAN						
ANGOLA						
BANGLADESH						
BELIZE						
BHUTAN						
BURKINA FASO						
CHAD						
DJIBOUTI						
EQUATORIAL GUINEA						
ERITREA						
ETHIOPIA						
GAMBIA						
GUINEA-BISSAU						
GUYANA						
HAITI						
HONDURAS						
INDIA						
KAZAKHSTAN						
KENYA						
KIRIBATI						
LIBERIA						
LIBYA						
MADAGASCAR						
MALAWI						
MALDIVES						
MALI						
MARSHALL ISLANDS						
MAURITANIA						
MICRONESIA						
MOROCCO						
MOZAMBIQUE						
MYANMAR						
NAMIBIA						
NICARAGUA						
NIGER						
NIGERIA						
NORTH KOREA						
PAKISTAN						
PAPUA NEW GUINEA						
SAMOA						
SAO TOME AND PRINCIPE						
SENEGAL						
SIERRA LEONE						
SOLOMON ISLANDS						
SOMALIA						

WEATHER DISASTERS 2010	WEATHER DISASTERS 2030	WEATHER FACTOR CHANGE	HABITAT LOSS 2010	HABITAT LOSS 2030	HABITAT FACTOR CHANGE	ECONOMIC STRESS 2010	ECONOMIC STRESS 2030	ECONOMIC FACTOR CHANGE
Acute+	Acute+	Stable	High+	Acute+	Increase	Moderate	High-	Stable
Moderate	High-	Stable	High-	High+	Stable	Severe-	Acute-	Slight increase
Acute+	Acute+	Stable	Moderate	High-	Stable	High-	High+	Stable
High+	Acute-	Slight increase	High+	Severe-	Stable	High+	Acute+	Slight increase
Severe+	Acute+	Slight increase	High+	Acute+	Increase	High-	High-	Stable
Moderate	Moderate	Stable	Severe+	Acute+	Slight increase	Severe+	Acute-	Stable
Moderate	High-	Stable	High+	Acute+	Slight increase	Severe-	Severe+	Stable
Acute+	Acute+	Stable	High-	High+	Stable	Severe-	Acute-	Slight increase
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Severe-	Severe+	Stable
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Severe+	Acute-	Stable
Moderate	High-	Stable	High-	Severe-	Slight increase	Severe+	Acute-	Stable
High-	High+	Stable	Severe+	Acute+	Slight increase	Severe-	Acute-	Slight increase
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Severe+	Acute+	Slight increase
Severe-	Acute-	Slight increase	Acute-	Acute+	Slight increase	Severe-	Acute+	Slight increase
Acute+	Acute+	Stable	High+	Acute+	Slight increase	Moderate	Moderate	Stable
Acute+	Acute+	Stable	High-	High-	Stable	High-	Severe+	Slight increase
Moderate	Moderate	Stable	High+	Acute+	Increase	High-	High-	Stable
Moderate	Moderate	Stable	Acute-	Acute+	Slight increase	Acute+	Acute+	Stable
Moderate	Moderate	Stable	High-	Acute-	Slight increase	Severe-	Acute-	Slight increase
Moderate	Moderate	Stable	Acute+	Acute+	Stable	High-	Acute+	Increase
Moderate	Moderate	Stable	High+	Severe-	Stable	High+	Severe-	Stable
Moderate	Moderate	Stable	Severe-	Acute+	Slight increase	Acute-	Acute+	Stable
Moderate	High-	Stable	Acute-	Acute+	Slight increase	Severe+	Acute+	Slight increase
High-	High-	Stable	Moderate	Moderate	Stable	Severe+	Acute+	Slight increase
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Severe-	Acute+	Slight increase
Moderate	Moderate	Stable	Severe-	Acute+	Slight increase	Severe-	Severe+	Stable
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Acute-	Acute+	Slight increase
Moderate	Moderate	Stable	Acute+	Acute+	Stable	High+	Severe-	Stable
Acute+	Acute+	Stable	High+	Severe+	Slight increase	High-	Acute-	Slight increase
High+	Severe-	Stable	High-	Severe+	Slight increase	Acute-	Acute+	Slight increase
High+	Severe-	Stable	Acute+	Acute+	Stable	Severe+	Acute+	Slight increase
Acute+	Acute+	Stable	High+	Acute+	Slight increase	Severe-	Acute+	Slight increase
High+	Severe-	Stable	Acute+	Acute+	Stable	Severe-	Acute+	Slight increase
Acute-	Acute+	Slight increase	Severe-	Severe+	Stable	High-	Severe+	Slight increase
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Severe-	Severe+	Stable
Moderate	Moderate	Stable	High+	Acute-	Slight increase	Severe-	Severe+	Stable
Severe-	Acute+	Slight increase	Severe-	Severe-	Stable	Low	Low	Stable
Severe-	Severe-	Stable	High+	Acute+	Increase	High-	High-	Stable
Moderate	Moderate	Stable	High+	Severe-	Stable	Severe-	Acute+	Slight increase
Severe+	Acute+	Slight increase	High+	Severe-	Stable	High-	Severe-	Slight increase
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Moderate	High-	Stable
Moderate	Moderate	Stable	Acute+	Acute+	Stable	Severe-	Acute+	Slight increase
Moderate	High-	Stable	Severe-	Acute+	Slight increase	Severe-	Acute-	Slight increase
High-	High+	Stable	Acute+	Acute+	Stable	High+	Acute+	Increase
Acute+	Acute+	Stable	Acute+	Acute+	Stable	Severe+	Acute-	Stable

Acute+ Acute Acute- Severe+ Severe Severe- High+ High High- Moderate Low
Increase Slight increase Stable Slight decrease Decrease

	COUNTRY	OVERALL VULNERABILITY FACTOR 2010	OVERALL VULNERABILITY FACTOR 2030	OVERALL CHANGE IN IMPACT	HEALTH IMPACT 2010	HEALTH IMPACT 2030	HEALTH FACTOR CHANGE
ACUTE	SUDAN						
	SURINAME						
	TANZANIA						
	TIMOR-LESTE						
	UGANDA						
	VANUATU						
	VIETNAM						
	YEMEN						
	ZIMBABWE						
SEVERE	ALGERIA						
	ANTIGUA AND BARBUDA						
	BAHAMAS						
	BENIN						
	BOLIVIA						
	BOTSWANA						
	BURUNDI						
	CAMBODIA						
	CAMEROON						
	CAPE VERDE						
	CENTRAL AFRICAN REPUBLIC						
	CONGO						
	COTE D'IVOIRE						
	DRC CONGO						
	GRENADA						
	GUINEA						
	IRAQ						
	MONGOLIA						
	NEPAL						
	RWANDA						
	SEYCHELLES						
	SOUTH AFRICA						
	SWAZILAND						
	TAJIKISTAN						
	TOGO						
	TUNISIA						
	TUVALU						
	ZAMBIA						
HIGH	ALBANIA						
	ARMENIA						
	AZERBAIJAN						
	BELARUS						
	BOSNIA AND HERZEGOVINA						
	BULGARIA						
	CHINA						
	COMOROS						
	CROATIA						

WEATHER DISASTERS 2010	WEATHER DISASTERS 2030	WEATHER FACTOR CHANGE	HABITAT LOSS 2010	HABITAT LOSS 2030	HABITAT FACTOR CHANGE	ECONOMIC STRESS 2010	ECONOMIC STRESS 2030	ECONOMIC FACTOR CHANGE
High-	High-	→	High+	Acute+	↑	Acute-	Severe+	→
High-	High-	→	Acute+	Acute+	→	High+	Acute-	↗
Moderate	Moderate	→	High-	Acute-	↗	Severe+	Acute+	↗
Moderate	Moderate	→	Acute-	Acute+	↗	High-	Acute+	↗
Moderate	Moderate	→	Moderate	Moderate	→	Severe+	Acute+	↗
High-	Acute-	↗	Acute+	Acute+	→	Acute-	Acute+	↗
High+	Acute-	→	High+	Severe+	↗	Severe+	Acute+	↗
Acute-	Severe+	→	Moderate	High-	→	High-	Acute-	↗
Moderate	Moderate	→	Severe-	Acute+	→	High-	Severe-	→
High-	High+	→	Moderate	High-	→	Acute+	Acute+	→
High+	Acute-	↗	High-	High+	→	Moderate	High-	→
High-	High+	→	High+	Acute+	↑	High-	High-	→
Moderate	Moderate	→	Moderate	High-	→	Acute-	Severe+	→
Acute-	Severe+	→	Low	Low	→	High-	High+	→
Moderate	Moderate	→	Acute+	Acute+	→	High+	Acute+	→
Moderate	Moderate	→	Moderate	Moderate	→	Severe+	Acute-	→
High+	Acute-	→	High-	High-	→	Severe+	Acute+	↗
Moderate	Moderate	→	Moderate	High+	↗	High+	Severe+	→
Moderate	Moderate	→	Acute-	Acute-	↗	High+	Severe+	→
Moderate	Moderate	→	Moderate	Moderate	→	Severe+	Acute+	→
Moderate	Moderate	→	Moderate	Moderate	→	High+	Severe+	↗
Moderate	Moderate	→	Moderate	Moderate	→	High+	Acute+	→
Acute-	Acute+	↗	High-	High+	→	Moderate	Acute-	→
Moderate	Moderate	→	High-	Acute+	→	Moderate	High-	→
Moderate	Moderate	→	High-	Acute-	↗	High+	High-	→
Acute-	Acute-	↗	High+	Acute+	↑	Low	Low	→
High-	Severe-	↗	Moderate	Moderate	→	Moderate	High-	→
Moderate	Moderate	→	Moderate	Moderate	→	Severe+	Severe+	↗
Moderate	High-	→	High-	Acute+	→	Severe+	Acute-	→
Moderate	Moderate	→	Acute+	Acute+	→	High-	Acute+	↗
High-	High+	→	Low	Low	→	Acute+	Acute+	→
Moderate	Moderate	→	Moderate	Moderate	→	Severe-	Severe+	↗
Moderate	Moderate	→	High-	High+	→	Severe+	Severe+	→
Moderate	Moderate	→	Moderate	Moderate	→	Acute+	Acute+	→
Moderate	Moderate	→	Low	Low	→	Acute+	Acute+	→
Moderate	Moderate	→	Low	Low	→	Acute+	Acute+	→
Moderate	Moderate	→	Moderate	Moderate	→	Acute+	Acute+	→
Moderate	Moderate	→	Moderate	Moderate	→	Acute+	Acute+	→
Moderate	Moderate	→	Low	Low	→	Severe-	Acute+	↗
Moderate	High-	→	High-	Acute+	↗	Low	Low	→
Moderate	Moderate	→	Severe-	Severe+	→	Moderate	High-	→
Moderate	Moderate	→	Moderate	Moderate	→	Acute-	Acute+	→

Acute+ Acute Acute- Severe+ Severe Severe- High+ High High- Moderate Low

Increase Slight increase Stable Slight decrease Decrease

	COUNTRY	OVERALL VULNERABILITY FACTOR 2010	OVERALL VULNERABILITY FACTOR 2030	OVERALL CHANGE IN IMPACT	HEALTH IMPACT 2010	HEALTH IMPACT 2030	HEALTH FACTOR CHANGE
HIGH	CUBA						
	DOMINICA						
	DOMINICAN REPUBLIC						
	ECUADOR						
	EGYPT						
	EL SALVADOR						
	ESTONIA						
	FIJI						
	GABON						
	GEORGIA						
	GHANA						
	GUATEMALA						
	HUNGARY						
	INDONESIA						
	IRAN						
	JORDAN						
	KYRGYZSTAN						
	LAOS						
	LESOTHO						
	LITHUANIA						
	MACEDONIA						
	MAURITIUS						
	MOLDOVA						
	PALAU						
	PANAMA						
	PERU						
	PHILIPPINES						
	ROMANIA						
	RUSSIA						
	SAINT VINCENT AND THE GRENADINES						
	SLOVAKIA						
	SLOVENIA						
	SPAIN						
	SYRIA						
	THAILAND						
	TONGA						
	TURKMENISTAN						
	UKRAINE						
	UNITED STATES OF AMERICA						
	UZBEKISTAN						
	VENEZUELA						
MODERATE	ARGENTINA						
	AUSTRALIA						
	BAHRAIN						
	BARBADOS						
	BRAZIL						

WEATHER DISASTERS 2010	WEATHER DISASTERS 2030	WEATHER FACTOR CHANGE	HABITAT LOSS 2010	HABITAT LOSS 2030	HABITAT FACTOR CHANGE	ECONOMIC STRESS 2010	ECONOMIC STRESS 2030	ECONOMIC FACTOR CHANGE
High	Severe+	Slight increase	Moderate	Moderate	Stable	High-	High-	Stable
High	Acute-	Slight increase	High-	High+	Stable	Moderate	Moderate	Stable
Acute-	Acute+	Stable	Low	Low	Stable	High-	High-	Stable
High	High+	Slight increase	Low	Low	Stable	High+	Severe-	Slight increase
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Stable
High-	Severe-	Slight increase	Moderate	Moderate	Stable	High-	High+	Stable
Moderate	Moderate	Stable	High-	High+	Stable	Severe-	Severe-	Stable
High-	High+	Stable	High+	High+	Stable	High-	Severe-	Slight increase
Moderate	Moderate	Stable	High-	High+	Stable	High+	Severe-	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	High-	High+	Stable
Moderate	High-	Stable	Moderate	High-	Stable	Severe+	Severe+	Slight increase
Moderate	Moderate	Stable	Moderate	Moderate	Stable	High-	High-	Stable
Moderate	High-	Stable	High-	Severe+	Slight increase	Moderate	High-	Stable
Moderate	Moderate	Stable	Severe	High+	Slight increase	High-	High-	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Slight increase
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Slight increase
High	High	Stable	Low	Low	Stable	High-	High-	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Slight increase
High-	High-	Stable	High-	High-	Stable	High-	Severe+	Slight increase
High-	High-	Stable	Low	Low	Stable	High-	Severe-	Stable
High-	High-	Stable	High-	High-	Stable	Severe+	Severe+	Slight increase
High-	Severe-	Slight increase	Moderate	Moderate	Stable	Severe+	Severe+	Slight increase
High-	High-	Stable	Moderate	Moderate	Stable	High+	High+	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Slight increase
High-	High+	Stable	High+	Severe-	Stable	Moderate	High-	Stable
Moderate	Severe-	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Slight increase
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Severe+	Severe+	Slight increase
Moderate	Moderate	Stable	High+	Severe-	Slight increase	Moderate	Moderate	Stable
Moderate	Moderate	Stable	High+	Severe-	Increase	High-	High-	Stable
High-	High-	Stable	Moderate	Moderate	Stable	Severe-	Severe+	Slight increase
Moderate	High-	Stable	High+	Severe-	Stable	Moderate	High-	Stable
Moderate	Moderate	Stable	Low	Low	Stable	Severe+	Severe+	Stable
Moderate	Moderate	Stable	Low	Low	Stable	Severe+	Severe+	Stable
Moderate	Moderate	Stable	Severe-	Severe-	Slight increase	High-	High-	Stable
Moderate	Moderate	Stable	Low	Low	Stable	Severe+	Severe+	Stable
Severe+	Severe+	Stable	Low	Low	Stable	High-	High+	Stable
Moderate	Moderate	Stable	Low	Low	Stable	High-	High-	Stable
Moderate	Moderate	Stable	High-	High+	Stable	Moderate	High-	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	High-	High-	Stable
Moderate	Moderate	Stable	Moderate	Moderate	Stable	Moderate	High-	Stable
Moderate	Moderate	Stable	Low	Low	Stable	High-	High+	Stable

Acute+ Acute Acute- Severe+ Severe Severe- High+ High High- Moderate Low

Increase Slight increase Stable Slight decrease Decrease

	COUNTRY	OVERALL VULNERABILITY FACTOR 2010	OVERALL VULNERABILITY FACTOR 2030	OVERALL CHANGE IN IMPACT	HEALTH IMPACT 2010	HEALTH IMPACT 2030	HEALTH FACTOR CHANGE
MODERATE	BRUNEI						
	CANADA						
	CHILE						
	COLOMBIA						
	COSTA RICA						
	CYPRUS						
	CZECH REPUBLIC						
	ICELAND						
	ISRAEL						
	JAMAICA						
	KUWAIT						
	LATVIA						
	LEBANON						
	MALAYSIA						
	MEXICO						
	OMAN						
	PARAGUAY						
	POLAND						
	QATAR						
	SAINT LUCIA						
	SAUDI ARABIA						
	SINGAPORE						
	SOUTH KOREA						
	SRI LANKA						
	TRINIDAD AND TOBAGO						
	TURKEY						
	UNITED ARAB EMIRATES						
	URUGUAY						
LOW	AUSTRIA						
	BELGIUM						
	DENMARK						
	FINLAND						
	FRANCE						
	GERMANY						
	GREECE						
	IRELAND						
	ITALY						
	JAPAN						
	LUXEMBOURG						
	MALTA						
	NETHERLANDS						
	NEW ZEALAND						
	NORWAY						
	PORTUGAL						
	SWEDEN						
	SWITZERLAND						
	UNITED KINGDOM						

WEATHER DISASTERS 2010	WEATHER DISASTERS 2030	WEATHER FACTOR CHANGE	HABITAT LOSS 2010	HABITAT LOSS 2030	HABITAT FACTOR CHANGE	ECONOMIC STRESS 2010	ECONOMIC STRESS 2030	ECONOMIC FACTOR CHANGE
Low	Low	→	Low	Low	→	High+	Severe-	→
Low	Low	→	Low	High-	→	Low	High-	→
Low	High-	→	Low	Low	↘	High-	High+	→
High-	High+	→	Low	Low	→	High+	High+	→
High-	High-	→	Low	Low	→	High-	High+	→
Low	Low	→	Low	Low	→	Low	Low	→
Low	Low	→	Low	Low	→	Severe+	Acute-	→
Low	Low	→	High+	Severe-	→	Low	Low	→
Low	Low	→	Low	High-	→	High-	High-	→
High-	High-	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Severe-	Severe-	→
Low	Low	→	Low	Low	→	High-	High-	→
Low	Low	→	Low	Low	→	High+	Severe+	↗
Low	High-	→	Low	Low	→	High-	High-	→
High-	High+	→	Low	Low	→	High-	High-	→
Low	Low	→	Low	Low	→	High-	High-	→
Low	Low	→	Low	Low	→	Severe+	Acute-	→
Low	Low	→	Low	Low	→	High-	High-	→
Low	Low	→	Low	High-	→	Low	Low	→
Low	Low	→	Low	Low	→	High-	High-	→
Low	Low	→	Low	Low	→	High+	Severe-	→
Low	High-	→	Low	Low	→	Low	Low	→
High-	High-	→	Low	Low	→	Low	High+	→
Low	Low	→	Low	Low	→	Low	Low	→
Low	Low	→	Low	High+	↗	High-	High-	→
Low	Low	→	Low	Low	→	High-	High-	→
Low	Low	→	High-	High-	→	High-	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	Low	↘
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	Low	→
Low	Low	→	Low	Low	→	Low	Low	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	High-	High-	→
Low	Low	→	Low	Low	→	Low	Low	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	High-	→
Low	Low	→	Low	Low	→	Low	Low	↘
Low	Low	→	Low	Low	→	Low	Low	→
Low	Low	→	Low	Low	→	Low	Low	→
Low	Low	→	Low	Low	→	High-	High-	→
Low	Low	→	Low	Low	→	Low	Low	→

Acute+ Acute Acute- Severe+ Severe Severe- High+ High High- Moderate Low

Increase Slight increase Stable Slight decrease Decrease

Victims of floods in Pakistan walk through water-filled streets in Nowshera. Source: UN Photo/WFP/ Amjad Jamal.

CLIMATE BASICS

"Climate" means average weather conditions, usually over a period of 30 years.[356] "Climate change" is the altering of these conditions. Humanity is extraordinarily sensitive to climate, and civilization might not have emerged without the warm, stable weather conditions that have prevailed since the end of the last ice age more than 10,000 years ago. That stability has collapsed over the last few decades, and now weather conditions are spiralling out of control. If we do not take action now to stop climate change, destructive weather will bring devastation capable of forever destroying much of our planet and the life it supports.

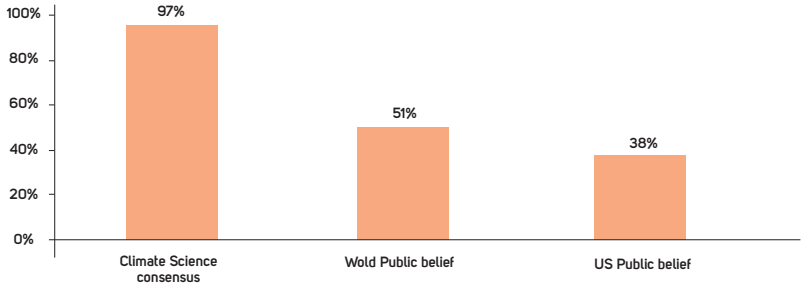
THE CONSENSUS

Climate change, in particular global warming, is an indisputable fact.[357] Scientists overwhelmingly agree that pollution is the main cause of this change.[358]

Recent study has shown that there is scientific consensus on climate change among more than 97% of experts actively publishing on the topic.[359] Other studies have revealed no trace of climate denial in hundreds of mainstream scientific articles.[360] Such a high level of agreement among specialists is equal to the scientific consensus supporting the understanding that smoking is a risk factor for lung cancer.[361]

The Intergovernmental Panel on Climate Change (IPCC) – the world's leading authority on the issue – pooled the work of more than 2,000 experts in its last major report in 2007.

ARE SCIENTIST IN AGREEMENT?



Source: World Bank, world Development Report 2010: Development and Climate Change

A handful of errors recently uncovered from among the vast quantities of information covered in the report have not put the Panel's main findings into question. Discussions on how to reform the IPCC's working methods are ongoing. And prominent critics have found the IPCC's conclusions conservative or accurate in varying degrees.[362]

The most authoritative academic bodies from around the world all support the IPCC and the basic consensus on climate change.[363] In 2001, the Bush Administration asked the US National Academy of Sciences to examine the question, and it responded in clear support of the prevailing consensus.[364] As The Royal Society in the UK pointed out, those who disagree with the consensus on climate change have failed to put forward any competing models.[365]

And yet the consensus among specialists contrasts starkly with the opinion of the general public. Only half of the world's population, and as little as 38% of the US population (depending on the study used), believes scientists are in consensus.[366]

The complexity of the subject is partially to blame. Mainstream media may also be contributing to the public's lack of awareness about climate change. Most people form their opinions about science through debate in the media. But the principle of "balanced reporting" automatically gives disproportionate emphasis to climate scepticism out of fairness to a side of the argument that no longer exists.[367]

The serious discord between science and the general public is a travesty given how important public opinion is in mobilizing the type of political action so desperately needed to tackle climate change today.

THE CAUSES

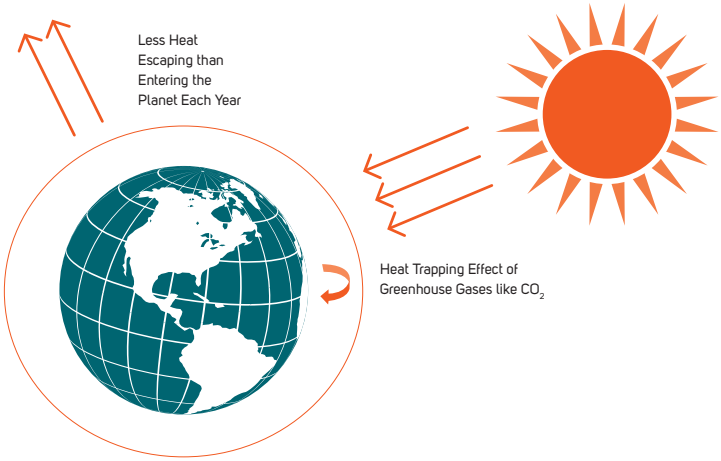
The well-known greenhouse effect is a perfectly natural characteristic of our planet that sustains life. Gases such as water vapour, CO_2, methane, and others cover the earth's surface closely like a blanket, slowing the escape of heat into the boundlessly freezing universe outside of the planet's atmosphere. Without this "blanket" the planet's average surface temperature (now 14 degrees Celsius or 57 degrees Fahrenheit) would be 30 degrees Celsius or 60 degrees Fahrenheit colder.[358]

If our climate were stable, the planet would see no real loss or gain of heat into outer space over the course of a year. But we are in imbalance, with slightly more heat entering earth (from the sun) every year than is leaving it.[369]

This global warming is happening because we are creating more heat-trapping greenhouse gases than in the past. We do so because the basic activities of human society -- from energy production, transport, and industry to deforestation -- all produce greenhouse gases.[370]

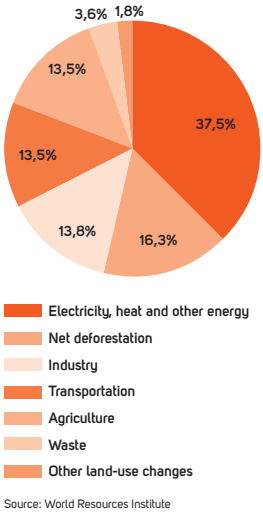
More greenhouse gases mean a stronger greenhouse effect, with less heat escaping back into outer space, and a hotter planet.

According to records of the last 400,000 years of the earth's past, every major peak or trough in temperature has been accompanied by a peak or trough in greenhouse gases such as CO_2.[371] Today's CO_2 levels exceed anything seen over this time.[372]



SOURCE OF GREENHOUSE GAS EMISSIONS

Emissions from Human Activities - CO_2 equivalent. 2000



Source: World Resources Institute

THE CHANGES

Our earth has warmed by roughly 0.8 degrees Celsius or 1.4 degrees Fahrenheit since the industrial revolution, when serious levels of pollution began. CO_2 levels have grown by more than 30% since that time and continue to grow every year.[373]

But most of the change has taken place since the 1970 and 80s. The last three decades are clearly the hottest on record since 1850.[374] And of the 20 hottest years on record, only three were before the 1990s (they were in the 1980s).[375]

The heating up of the atmosphere is causing a variety of other major environmental changes, such as warmer oceans and widespread melting of glaciers and ice. Since 1980, all of the world's glaciers have either been in long-term retreat or have disappeared.[376]

The melting of ice and the heating up of the earth's oceans -- which expand as they warm -- contribute to a rise in global sea-levels. And sea-level rise has doubled in speed over just the last few decades.[377]

We see shocking evidence of change in the Arctic. Most of the Arctic is ocean. In 1980, Arctic ice covered a minimum area of 7 million square kilometres, or around 3 million square miles, of that ocean during the height of summer. By 2007, that area had halved to just 3.5 million square kilometres, or less than 1.5 million square miles.[378]

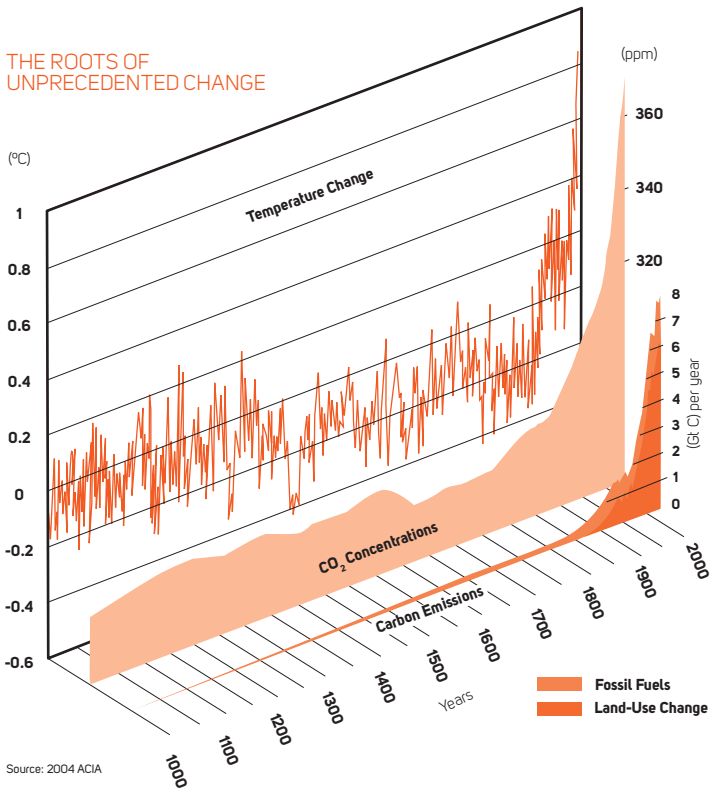
The Arctic region, when defined as an area of consistently cold temperatures, has actually been retreating toward the North Pole at a rate of some 35 miles or 56 kilometres per decade over the last 30 years.[379]

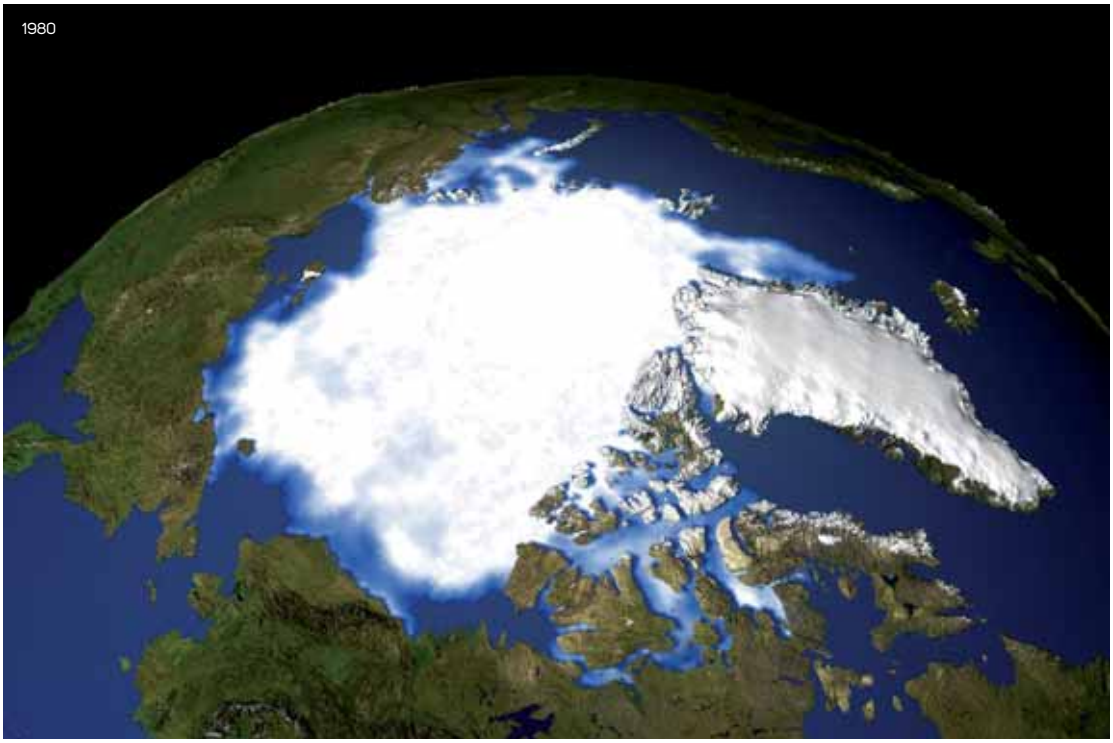
Many of these changes are self-reinforcing, establishing a vicious cycle that will continue to accelerate climate change. In the Arctic, for instance, less sea ice means less heat reflected back into space, and warmer oceans absorb less heat and CO_2, leaving more of both in the atmosphere. Worse still, as the Arctic region shrinks, otherwise permanently frozen land (permafrost) on its margins could release up to a billion tons of greenhouse gases per year as it thaws (or some 3% of today's global emissions).[380]

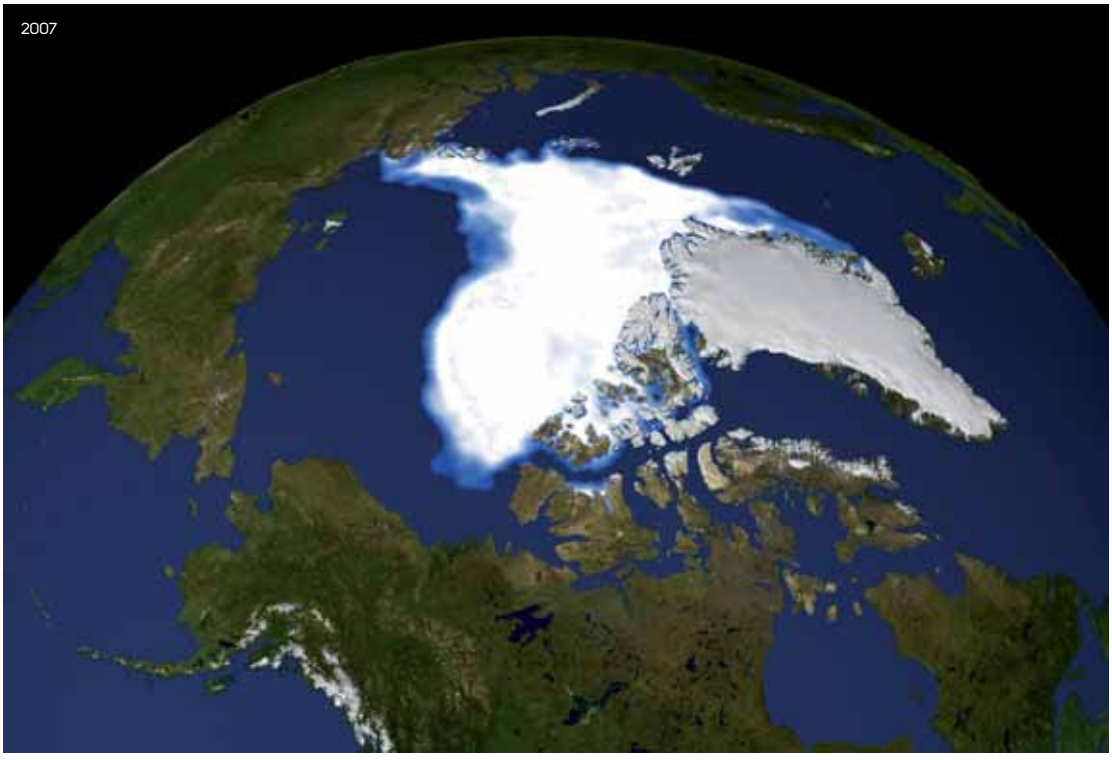
Not all changes are felt the same everywhere. Rainfall, for instance, is increasing due to higher temperatures, which cause moisture to evaporate faster.[381] But while northern parts of America, Asia and Europe, as well as much of South America have experienced increases in rain, areas of Africa, the Mediterranean, and Asia have seen rainfall drop as weather patterns shift.[382]

Other effects include more hot days and nights, more heat waves and heavy rain, more flooding and more drought.[383]

All of these changes have profound effects on plant and animal life, including significant adverse effects on biodiversity (such as species extinctions) and, of course, on human populations, which is a key topic of this report.[384]







Source: NASA

THE MOMENTUM

None of these changes shows any sign of slowing. Quite the opposite: One of the largest ever symposiums on climate science, held in Copenhagen in March 2009, concluded that, in most areas, change was happening at the upper estimates or faster than foreseen by scientists only two years earlier.[385]

Greenhouse gases, rises in average temperatures and sea-levels, disappearing ice and glaciers, and other indicators of change far exceed anything seen over much of the last million years of life on earth.[386] And much of that change has occurred over the last 30 years.[387]

Temperature fluctuations have occurred over the past millennia, but civilization emerged during a period of relative stability in climate.[388]

While a stable climate has allowed life on earth to flourish, an unstable climate can have the opposite effect. Increasingly, rapid change is outstripping the ability of the environment, animal life, and human society to naturally adapt. Plant and animal species rendered extinct will not return. And many of the effects of an unstable climate are compounded by factors such as population growth and increasing consumer consumption, which already strain the planet's ability to support some 7 billion people and counting.

It's important to note that there is a long delay between any increase or decrease in greenhouse gases and a corresponding warming or cooling effect on the planet. This is mainly because the earth's oceans absorb heat but only release it back into the atmosphere over a series of decades. So continued production of greenhouse gases doesn't just mean a warmer planet today, but a continuous heating up of our planet for years to come.

There is currently enough heat in the oceans to cause an additional 0.6 degrees Celsius or one degree Fahrenheit of warming over the next decades even if we were to stop emitting greenhouse gases today.[389] That means 1.4 degrees Celsius or 2.5 degrees Fahrenheit of warming is already unavoidable and something we must accept.[390] Depending on the amount of pollution we continue to release, we could well reach that temperature by 2030.[391] This fact not only underscores the necessity of acting well in advance to reduce emissions but also compels us to prepare for the far greater impacts of climate change that will hit us during the coming 20 years.

1.4 DEGREES CELSIUS OR 2.5 DEGREES FAHRENHEIT OF WARMING IS ALREADY UNAVOIDABLE AND SOMETHING WE MUST ACCEPT

THE WINDOW OF OPPORTUNITY

The international community has agreed that 2 degrees Celsius or 3.6 degrees Fahrenheit of warming above pre-industrial levels is a threshold we must not exceed.[392] There are legitimate fears that over-passing that level could cause irreversible changes to the earth's climate -- termed "runaway climate change" -- that feed back into themselves in a self-perpetuating cycle of warming no longer stoppable by emission reductions.[393] Even at that level however, we could see the extinction of 30% of the planet's species, the disappearance of the world's coral reefs, and severe water shortages and hunger for hundreds of millions of people.[394]

Greenhouse gases are measured in parts per million (ppm). They amount to about 390 ppm today and are growing at roughly 2 ppm per year.[395] The IPCC recommends limiting greenhouse gas concentrations to 400 ppm in order to avoid 2-2.4 degrees Celsius or 3.6-4.3 degrees Fahrenheit of warming. That would mean halting all emissions in a matter of just a few years, which is unrealistic given that emissions currently grow at a rate of around 3% per year.[396]

But if we delay action until after 2020, we will be faced with having to make enormous emission reductions of 5% per year just to have a chance at keeping to the internationally recognized safety threshold.[397]

Decisive and comprehensive action must begin now. If not, massive costs linked both to hasty emission reductions and/or colossal and irreversible impacts of climate change will be inevitable. The costs of climate change in human, economic, and environmental terms as outlined in this report are only a shadow of what humanity will face in the years to come.

Hurricane Dennis batters palm trees and floods parts of Naval Air Station Key West's Truman Annex in the United States. Source: U.S. Navy/Jim Brooks.

RESEARCH GAPS

Important research gaps limit our understanding of the impact of climate change on human society. That equally limits the effectiveness of our response to counteracting its negative effects, as well as our understanding of the true extent of the climate crisis. Significant resources should be channelled urgently into addressing these and other key shortcomings in our understanding of climate vulnerability

THE MONITOR QUANTIFICATION/ ATTRIBUTION ISSUES

Quantitatively attributing impacts to climate change will be of vital importance to preparing any response that seeks to address the added stresses triggered by global warming. Such quantifications are particularly weak in the area of extreme weather, especially tropical cyclones, where scientists still disagree on the extent of the observed intensification effect on major storms, especially in the North Atlantic. Quantification must go far beyond measures of changes in the actual physical effects -- such as storm intensity, frequency, or spatial occurrence variations -- to a more comprehensive understanding of the socio-economic and human effects that result from such changes, in particular as relates to possible threshold breaching or tipping-points when communities become overwhelmed as a result of just small excess pressures. The impact of climate change on marine fisheries is another major area of concern lacking any clear scientific quantification scenarios. Several other such areas are mentioned below under “Information Gaps”.

INFORMATION GAPS

Inadequate understanding of the impact dynamics of climate change on a number of key phenomenon with known climate sensitivities (negative and positive) require more thorough enquiry, including:

- Freshwater fisheries
- Habitat degradation to Arctic, alpine and high-latitude communities
- The full spectrum of climate-sensitive diseases, including in particular infection rates/morbidity and other infection dynamics
- Hail
- Mudslides (mass movement - wet)
- In the field of development: access to education, sanitation, and energy or school participation rates
- International trade
- Political stability
- Conflict
- Migration and displacement
- Service or industry sectors of the economy, such as transport, tourism, textiles, energy, brewing, plastics, and many other business fields potentially affected especially by pass-on effects of climate change

DATA

The Monitor relies on internationally standardized data sets. The lack of standardized disaster and impact accounting -- in particular, inconsistencies, socio-economic or cultural differences in reporting of disaster events, the number of affected people/people in need of emergency assistance, injuries, damage costs, and losses -- greatly limit comparability across the board. There is an urgent need to harmonize reporting and maintain stringent gathering and coverage of such information according to international standards. In other cases, data is reasonably reliable but irregularly updated, such as the comprehensive World Health Organization’s Global Burden of Disease Database (WHO). Some data in authoritative databases, such as CRED EM-DAT have likely inaccuracies. Several countries have been entirely excluded from the Climate Vulnerability Monitor because of gaps across almost every impact area, something that particularly affects very small countries and small island developing states.

SPATIAL SCALE

Information on sub-national scales varies hugely from country to country. Governments should prioritize national assessments of vulnerability down to the community scale, where impacts actually play out on society.

CLIMATE INFORMATION

Climate models vary enormously in their prediction of different mainstay climate effects, such as changes in rainfall or temperature over all time horizons, short, medium and longer term. More detailed information is needed about the way in which water vapour -- the main greenhouse gas -- behaves in the atmosphere under external climate forcing from non-natural sources. Further research should be devoted to improving understanding of the behaviour of water vapour and other key climate parameters in order to reduce uncertainty in models and improve advance planning. Another limitation is a major gap in ground-level climate information in low-income countries around the world, in particular in Africa. Filling the persisting ground-level data gaps via the widespread installation of meteorological/ hydrological monitoring equipment, in particular in Africa, would be a crucial contribution to enhancing the bases of climate information.

ADAPTATION PERFORMANCE REVIEW
POLICY EVALUATION
Currently no adequate theory exists that allows us to effectively measure the success of policy-making and adaptation efforts.

EVIDENCE BASE
The evidence base for the effectiveness of a number of key adaptive measures is very limited, and not all adaptive measures presently have cost-benefit or cost-effectiveness measures.

MONETARY AND NON-MONETARY VALUE
Greater emphasis could be given to both the monetary and the non-monetary value of adaptation polices and/or characteristics of adaptive capacity/resilience of communities, including social safety nets, community support networks, and other societal resources that improve the ability of populations to cope with shocks and changes in the climate.

BACKGROUND
An analytical undertaking such as the one conducted here, based on primary research sources and climate models, is by necessity limited by the underlying data and research. Furthermore, the Climate Vulnerability Monitor is also dependent on climate models such as the FUND model and the DIVA model. A disciplined effort has gone into ensuring that the best available research and data have been used and that only the most respected climate scientists have been referenced. The aim is to continuously improve the Monitor to make it ever more relevant to policy-makers in the context of evolving understanding of the impact of climate change on human society.

Member of a programme offering new farming techniques and inputs such as improved seeds and alternative drought-resistant crop varieties in Madagascar. Souce: Tomas de Mul/IRIN:

ACKNOWLEDGMENTS

ROSS MOUNTAIN, DIRECTOR GENERAL OF DARA

I would like to express my sincere thanks on behalf of DARA and its Board of Trustees, in particular to the many experts and concerned individuals without whose personal engagement amid extremely busy schedules this important project would not have been brought to fruition in 2010.

The Climate Vulnerability Monitor has been developed as a core part of the Climate Vulnerability Initiative partnership between DARA and the Climate Vulnerable Forum through its founder, the Republic of the Maldives. President Mohamed Nasheed founded the Climate Vulnerable Forum in 2009 to highlight the urgent concerns and hopes of the most vulnerable communities around the world. The support provided by the Maldives has been key in providing focus guidance and in engaging many important stakeholders in the development of the Monitor. Our warm thanks go to the Maldives Ministries of Foreign Affairs and of the Environment and to the Office of the President. Special thanks go to Minister Ahmed Shaheed, Minister of State Ahmed Naseem, Aminath Shauna, Paul Roberts, Deputy Minister Hawla Didi, Iruthisham Adam, Abdul Ghafoor Mohamed, Thilmeeza Hussain, Ahmed Shiaan, Amin Javed Faizal, Rose Richter, Fathimath Inaya, and Mariyam Midhfa Naeem. We are also most grateful to President Anote Tong of Kiribati and Foreign Secretary Tessie Lambourne, as well as to Foreign Secretary Mohamed Quayes, Mohammad Khastagir, Tareq Ahmed, and Faiyaz Murshid Kazi of Bangladesh.

Other members of the Climate Vulnerable Forum endorsed and encouraged this effort at their high-level meeting in New York on 19 September 2010, where it was decided the report should serve as a reference for advocacy and promoting policy development in the area of climate vulnerability. Attendees to the September meeting included senior representatives of Antigua and Barbuda, Bangladesh, Costa Rica, Kiribati, Grenada, Maldives, Marshall Islands, Nepal, Philippines, St. Lucia, Solomon Islands, Timor-Leste, and Samoa, who joined earlier signatories to the 2009 Climate Vulnerable Forum Declaration -- Barbados, Bhutan, Ghana, Kenya, Maldives, Rwanda, Tanzania, and Vietnam.

The guidance and insight provided by the Advisory Panel was invaluable. Its members, Mary Chinery-Hesse, Helen Clark, Jan Eliasson, José María Figueres Olsen, Saleemul Huq, Yolanda Kakabadse, Ashok Khosla, Ricardo Lagos, Loren Legarda, Ahmed Naseem, Rajendra Pachauri, Teresa Ribera, Johan Rockström, Hans Joachim Schellnhuber, Klaus Töpfer, Margareta Wahlström, and Michael Zammit Cutajar, generously contributed ideas and insights to the report.

In a field of expertise with still many uncertainties, the Peer Review Committee worked to ensure that the data presented in this document is based on a solid methodology. The detailed and prompt feedback received was indispensible for the robustness of the analysis achieved, and we are indebted to its members: Yasemin Aysan, Suruchi Bhadwal, Manuel Carballo, Diarmid Campbell-Lendrum, Ian Christoplos, Pierre Encontre, Anne Hammill, Juergen Kropp, Marc Levy, Bo Lim, Urs Luterbacher, Pascal Peduzzi, Hansjoerg Strohmeyer, and Farhana Yamin.

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Data Providers:
- World Health Organization (WHO)
- Centre for Research on the Epidemiology of Disasters (CRED) Emergency Events Database (EM-DAT)
- GermanWatch / MunichRe NatCatSERVICE
- Population, Landscape, and Climate Estimates (PLACE-II) / Center for International Earth Science Information Network (CIESIN) of Columbia University
- Dynamic and Interactive Vulnerability Assessment (DIVA) of the Potsdam Institute for Climate Impact Research (PIK)
- Climate Framework for Uncertainty, Negotiation and Distribution (FUND) model of Richard S. Tol and David Anthoff
- World Resources Institute (WRI) Database, Fisheries Exports
- World Bank 2008 for Gross Domestic Product (Purchasing Power Parity)

The report would not have been possible without the analytical expertise and dedicated work of Commons Consultants, the main research and production partner of DARA in this effort, a team led by Søren Peter Andreasen and including Jakob Mathias Wichmann, Peter Utzon Berg, Anne-Mette Steinmeier and Andreas Clemmensen and which was responsible in particular for developing the quantitative foundations of the report and contributing to its research base and substantive content.

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PARTNERS

The Climate Vulnerability Monitor benefits from the collaboration of its two lead partners, DARA and the Climate Vulnerable Forum at the core of the Climate Vulnerability Initiative. DARA brings specialist expertise and independent objectivity to the endeavour, building on its experience as a critical evaluator of development and humanitarian aid effectiveness. The Climate Vulnerable Forum and its members, particularly its initiating chair (the Maldives), have contributed prescient thought leadership to the project, as well as expertise from inside the climate frontlines.

DARA

DARA is an independent international organization committed to improving the quality and effectiveness of aid for vulnerable populations suffering from conflict, disasters, and climate change. It carries out this mandate through research, evaluations, and knowledge sharing. DARA was founded with the compelling vision of Silvia Hidalgo to enhance the impact of international assistance for the benefit of the most vulnerable of the world's groups. DARA created the Humanitarian Response Index, which is the premier evaluation tool for donor effectiveness in humanitarian assistance.

BOARD OF TRUSTEES

- Diego Hidalgo (Chairman)
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CLIMATE VULNERABLE FORUM

The Climate Vulnerable Forum convenes governments from Africa, Asia, the Americas, and the Pacific, representing some of the countries most vulnerable to the adverse impacts of climate change. The Forum first convened in the Maldives in November 2009 and adopted a declaration that expressed alarm at the pace of change to the Earth caused by climate change and committed to demonstrating leadership aimed at tackling what for some nations is becoming an existential challenge. The Climate Vulnerable Forum brings to the Monitor its strategic leadership engagement and facilitates access to key expertise.

COMMONS CONSULTANTS

Commons Consultants are the principal research and production partner of the Climate Vulnerability Initiative involved in the development of the Monitor. Commons Consultants is a management consulting and research firm with expertise in policy analysis and strategy development. Its focus industries are energy and environment, climate change, health, and responsible financial services.

DECLARATION OF THE CLIMATE VULNERABLE FORUM

We, Heads of State, Ministers and representatives of Government from Africa, Asia, Caribbean and the Pacific, representing some of the countries most vulnerable to the adverse impacts of climate change:

Alarmed at the pace of change to our Earth caused by human-induced climate change, including accelerating melting and loss of ice from Antarctica, Greenland, the Himalayas, Mount Kilimanjaro and Mount Kenya, acidification of the world's oceans due to rising CO_2 concentrations, increasingly intense tropical cyclones, more damaging and intense drought and floods, including Glacial Lakes Outburst Floods, in many regions and higher levels of sea-level rise than estimated just a few years ago, risks changing the face of the planet and threatening coastal cities, low lying areas, mountainous regions and vulnerable countries the world over;

Asserting that anthropogenic climate change poses an existential threat to our nations, our cultures and to our way of life, and thereby undermines the internationally-protected human rights of our people – including the right to sustainable development, right to life, the right to self-determination and the right of a people not to be deprived of its own means of subsistence, as well as principles of international law that oblige all states to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction;

Conscious that while our nations lie at the climate front-line and will disproportionately feel the impacts of global warming, in the end climate change will threaten the sustainable development and, ultimately, the survival of all States and peoples – the fate of the most vulnerable will be the fate of the world; and convinced that our acute vulnerability not only allows us to perceive the threat of climate change more clearly than others, but also provides us with the clarity of vision to understand the steps that must be taken to protect the Earth's climate system and the determination to see the job done;

Recalling that the UNFCCC is the primary international, intergovernmental forum for negotiating the global response to climate change;

Desirous of building upon the commitment of leaders at the recent United Nations High-Level Summit on Climate Change in New York in addressing the needs of those countries most vulnerable to the impacts of climate change as well as other political commitments, including the AOSIS Declaration and the African Common Position;

Underlining the urgency of concluding an ambitious, fair and effective global legal agreement at COP15 in Copenhagen;

Gravely concerned at reports of a downgrading of expectations for COP15 and calling therefore for a redoubling of efforts – including through the attendance in Copenhagen, at Head of State- or Head of Government-level, of all States, and especially of major industrialised nations and all major emerging economies;

Emphasising that developed countries bear the overwhelming historic responsibility for causing anthropogenic climate change and must therefore take the lead in responding to the challenge across all four building blocks of an enhanced international climate change regime – namely mitigation, adaption, technology and finance – that builds-upon the UNFCCC and its Kyoto Protocol;

Taking account of their historic responsibility as well as the need to secure climate justice for the world's poorest and most vulnerable communities, developed countries must commit to legally-binding and ambitious emission reduction targets consistent with limiting global average surface warming to well below 1.5 degrees Celsius above pre-industrial levels and long-term stabilisation of atmospheric greenhouse gas concentrations at well below 350ppm, and that to achieve this the agreement at COP15 UNFCCC should include a goal of peaking global emissions by 2015 with a sharp decline thereafter towards a global reduction of 85% by 2050;

Emphasising that protecting the climate system is the common responsibility of all humankind, that the Earth's climate system has a limited capacity to absorb greenhouse gas emissions, and that action is required by all countries on the basis of common but differentiated responsibilities, respective capabilities, and the precautionary principle; Underscoring that maintaining carbon-intensive

modes of production established in 19th Century Europe will incur enormous social and economic cost in the medium- and long-term, whereas shifting to a carbon-neutral future based on green technology and low-carbon energy creates wealth, jobs, new economic opportunities, and local co-benefits in terms of health and reduced pollution;

Convinced that those countries which take the lead in embracing this future will be the winners of the 21st Century;

Expressing our determination, as vulnerable States, to demonstrate leadership on climate change by leading the world into the low-carbon and ultimately carbon-neutral economy, but recognising that we cannot achieve this goal on our own;

Now therefore,

Declare our determination, as low-emitting countries that are acutely vulnerable to climate change, to show moral leadership on climate change through actions as well as words, by acting now to commence greening our economies as our contribution towards achieving carbon neutrality,

Affirm that this will enhance the objectives of achieving sustainable development, reducing poverty and attaining the internationally agreed development goals including the Millennium Development Goals,

Call upon all other countries to follow the moral leadership shown by the Republic of Maldives by voluntarily committing to achieving carbon-neutrality,

Assert that the achievement of carbon neutrality by developing countries will be extremely difficult given their lack of resources and capacity and pressing adaptation challenges, without external financial, technological and capability-building support from developed countries,

Declare that, irrespective of the effectiveness of mitigation actions, significant adverse changes in the global climate are now inevitable and are already taking place, and thus Parties to the UNFCCC must also include, in the COP15 outcome document, an ambitious agreement on adaptation finance which should prioritise the needs of the most vulnerable countries, especially in the near-term,

Call upon developed countries to provide public money amounting to at least 1.5% of their gross domestic product, in addition to innovative sources of finance, annually by 2015 to assist developing countries make their transition to a climate resilient low-carbon economy. This grant-based finance must be predictable, sustainable, transparent, new and additional – on top of developed country commitments to deliver 0.7% of their Gross National Income as Overseas Development Assistance,

Underline that financing for mitigation and adaptation, under the authority of the Conference of Parties to the UNFCCC, should be on the basis of direct access to implement country-led national Low-Carbon Development Plans and Climate Resilient Development Strategies, and the process to allocate and deliver the finance must be accessible, transparent, consensual, accountable, results-orientated and should prioritise the needs of the most vulnerable countries,

Further underline that fundamental principles and issues relating to the survival of peoples and preservation of sovereign rights are non-negotiable, and should be embedded in the Copenhagen legal agreement,

Call on Parties to the UNFCCC to also consider and address the health, human rights and security implications of climate change, including the need to prepare communities for relocation, to protect persons displaced across borders due to climate change-related impacts, and the need to create a legal framework to protect the human rights of those left stateless as a result of climate change,

Invite other vulnerable countries to endorse this Declaration,

Decide to hold a second meeting of the Climate Vulnerable Forum in Kiribati in 2010 to take forward this initiative, to further raise awareness of the vulnerabilities and actions of vulnerable countries to combat climate change, and to amplify their voice in international negotiations. In this context, request support from the UN system to assist the most vulnerable developing countries take action in pursuit of this Declaration.

Adopted in Male', Maldives,
10th November 2009

Bangladesh, Barbados, Bhutan, Ghana, Kenya, Kiribati, Maldives, Nepal, Rwanda, Tanzania, Vietnam

A girl attempting to fill containers with tricking water from a tap near an artesian well outside Yemen's capital, Sanaa. Source: Adel Yahya/IRIN.

GLOSSARY

ADAPTATION
In this report, adaptation refers to individual or governmental actions to reduce adverse effects or future risks associated with climate change. The IPCC/UNFCCC defines adaptation as the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

ADAPTATION PERFORMANCE REVIEW
Rating system of adaptive effectiveness that assesses measures known to be effective to a specific degree in limiting the impact on vulnerable populations as identified in the Climate Vulnerability Monitor/Index section of the report.

ADAPTIVE CAPACITY
The ability of a system to adjust to climate change, variability and extremes to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

AFFECTED COMMUNITIES
Communities that have seen their livelihoods compromised temporarily or permanently by climate change.

CLIMATE DISPLACED PEOPLE
Persons displaced temporarily or permanently due to climate change and its impacts or shocks, notably land desertification, sea-level rise and weather-related disasters. It is almost never possible to identify an individual as exclusively a climate displaced person due to the range of factors that are likely involved in forced or voluntary movement of people. Climate change, however, is still likely to generate additional numbers of migrants and displaced people.

CLIMATE EFFECT
Indicates the relative effects of climate change on social and economic variables at the country level. Climate effect (CE) is calculated based on observed values of social and economic variables and the effects of climate change.

CLIMATE IMPACT FACTOR
The relative contribution of climate change to the development of a given variable.

CLIMATE VULNERABILITY FACTOR
The aggregate vulnerability factor is determined as an evenly weighted sum of the independent vulnerability factors across the various impact areas. It indicates the extent to which countries are affected by multiple stresses.

CLIMATE VULNERABILITY MONITOR
The Climate Vulnerability Monitor provides a global overview of vulnerability to climate change. It provides fair estimates of the types of impacts we are already facing. It also shows where the impacts are taking place and captures our evolving global vulnerability to climate change.

COST-EFFECTIVENESS
Refers to the relationship between the economic input/cost of a given adaptation measure and the degree of beneficial output.

DEVELOPMENT AID
Aid to support the economic, social, and political development of developing countries. The aim is to alleviate poverty in the long run.

DISABILITY-ADJUSTED LIFE YEAR
This time-based measure combines years of life lost due to premature death and years of life lost due to time lived in states of less than full health. The DALY metric was developed in the original Global Burden of Disease 1990 study to assess the burden of disease consistently across diseases, risk factors, and regions.

DISASTER RISK REDUCTION
A framework for assessing various measures for minimizing vulnerabilities and disaster risks throughout a society, to avert (prevention) or limit (mitigation and preparedness) the adverse impacts of hazards within the broad context of sustainable development.[398]

ECONOMIC STRESS
The economic stress due to climate change captured in this report is based on fisheries, forestry, and other agricultural losses or gains. It is, to a great extent, driven by water resource impacts and climate effects on biodiversity.

EXPOSURE TO CLIMATE CHANGE
Exposure to physical manifestations of alterations in weather conditions and the environment as a result of climate change. See also “Vulnerability - Physical vulnerability to climate change”.

FOOD SECURITY
Refers to the availability of food and people’s access to it. A household is food secure when its occupants do not live in hunger or fear of starvation.

HABITAT LOSS
Refers to the loss of human habitats due to climate change impacts.

HEALTH IMPACT
The impacts of climate change that have an effect (positive or negative) on human health.

HUMANITARIAN ASSISTANCE
Material or logistical assistance provided for humanitarian purposes, typically in response to a humanitarian crisis. The aim is to alleviate suffering in the short term.

MITIGATION
Actions taken to lower greenhouse gas emissions targeted at reducing the extent of global warming. This is distinct from adaptation, which involves taking action to minimize the effects of global warming.

RESILIENCE
The ability of a community or ecosystem to recover from, return to equilibrium, or bounce back following a shock.

SOCIO-ECONOMIC IMPACT
Refers to climate change impacts of both social and economic character.

VULNERABILITY
The degree to which a community experiences danger and harm from the negative effects of climate change. Or: The degree to which a system (community, ecosystem, economy) is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC definition).

VULNERABILITY - PHYSICAL VULNERABILITY TO CLIMATE CHANGE
Refers to people who live in regions that are prone to more than one type of physical manifestation of climate change: floods, storms, droughts, sea-level rise, etc. (similar to “exposure”).

VULNERABILITY - SOCIO-ECONOMIC VULNERABILITY TO CLIMATE CHANGE
Refers to the capacity of individuals, communities, ecosystems, economies, and societies to adapt to climate change impacts and avoid suffering from long-term, potentially irreversible, losses in well-being and stability. Also referred to as “underlying vulnerabilities”.

WEATHER-RELATED DISASTERS
Natural disasters that are related to weather patterns, such as floods, droughts, and heat waves. Geophysical disasters such as earthquakes are not included in this category.

ABBREVIATIONS

CE: Climate effect

CIF: Climate impact factor

CO_2: Carbon dioxide

DALY: Disability-adjusted life year

DCPP: Disease Control Priorities Project

DIVA: Dynamic Interactive Vulnerability Assessment

ECA: [Working Group] Economics of Climate Adaptation Working Group

FAO: Food and Agriculture Organization

GDP: Gross domestic product

GEF: Global Environment Facility

GNP: Gross national product

GTZ: Deutsche Gesellschaft für Technische Zusammenarbeit

IFRC: The International Federation of Red Cross and Red Crescent Societies

IPCC: Intergovernmental Panel on Climate Change

MAD: Mean absolute deviation

MDGs: Millennium Development Goals

NAPA: National Adaptation Programme for Action

ORT: Oral rehydration therapy

PPP: Purchasing power parity

UNCCD: United Nations Convention to Combat Desertification

UNDP: United Nations Development Programme

UNEP: United Nations Environment Programme

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNFCCC: United Nations Framework Convention on Climate Change

UNICEF: United Nations Children's Fund

UNISDR: United Nations International Strategy for Disaster Reduction

WHO: World Health Organization

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4. Lucien Manga et al (2010)
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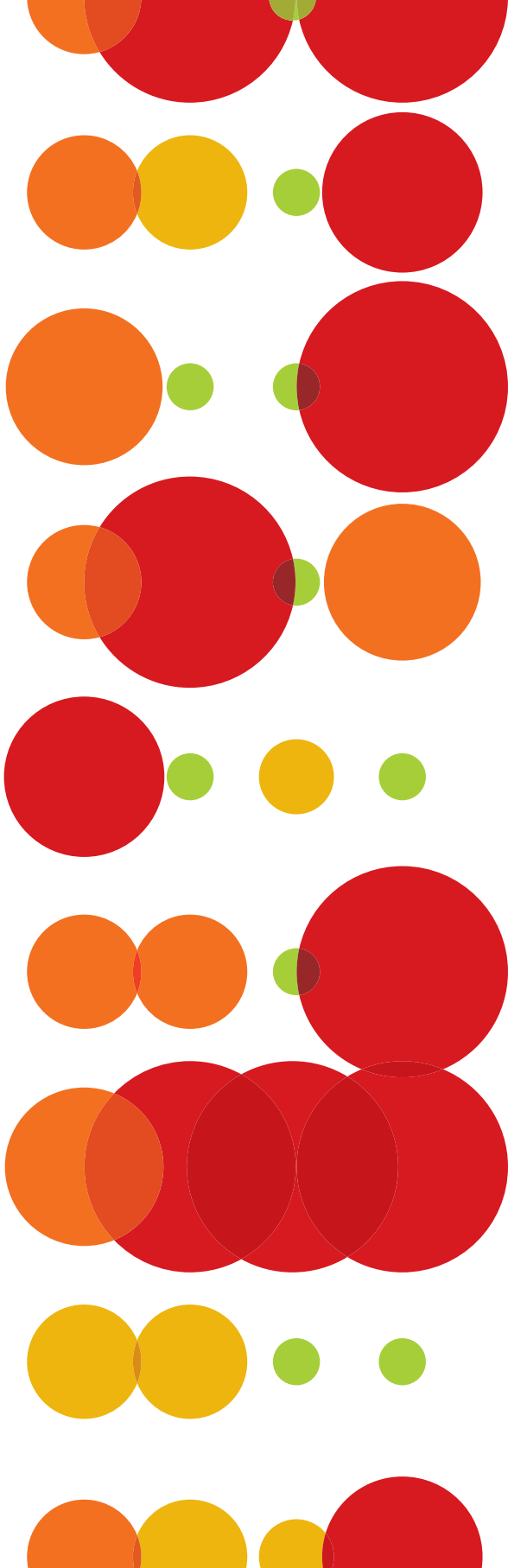

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